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FOURTEENTH ANNUAL REPORT

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION,

FOR 1895.

PRINTED BY ORDER OF THE STATE LEGISLATURE.

COLUMBUS, OHIO:
THE WESTBOTE CO., STATE PRINTERS.
1896.

TABLE OF CONTENTS.

Board of Control and Officers.

Announcement.

Report of the Secretary of the Board of Control.

Report of the Treasurer.

Report of the Director.

Report of the Agriculturist.

Report of the Horticulturist.

Report of the Entomologist.

Report of the Botanist.

Report of the Chemist.

Report of the Meteorologist.

Appendix—The Bulletin for 1895.

Index.

630.7
Oh33
v.14

ORGANIZATION OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

BOARD OF CONTROL.

SETH H. ELLIS	Springboro
R. H. WARDER	North Bend
J. T. ROBINSON	Rockaway
THE GOVERNOR OF THE STATE THE DIRECTOR OF THE STATION	*Ex-officio*

OFFICERS OF THE BOARD.

SETH H. ELLIS	President
R. H. WARDER	Secretary
PERCY A. HINMAN	Treasurer

STATION STAFF.

CHARLES E. THORNE	Wooster	Director
WILLIAM J. GREEN	“	Horticulturist and Vice-Director
J. FREMONT HICKMAN, M. A. S	“	Agriculturist
FRANCIS M. WEBSTER, M. Sc.	“	Entomologist
AUGUSTINE D. SELBY, B. Sc.	“	Botanist and Chemist
PERCY A. HINMAN	“	Bursar
WILLIAM HOLMES	“	Foreman of Farm
CHARLES A. PATTON	“	Ass't Foreman and Meteorologist
W. A. PORTER	“	Florist
H. O. McFADDEN	“	Foreman of Gardens
WILLIS G. HARRY	“	Dairyman
ANNIE B. AYRES	“	Mailing Clerk
S. J. BLAKE	“	Mechanic
J. E. BARCLAY	Neapolis	Supt. Northwestern Sub-Station
EDWARD MOHN	Strongsville	Supt. Northeastern Sub-Station

The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

XX97
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Announcement.

The Ohio Agricultural Experiment Station is organized under an act of the General Assembly of Ohio, passed April 17, 1882, and supplemented by an act of Congress approved March 2, 1887.

The Station is prepared to test new varieties of grains, fruits and garden vegetables; to examine seeds that are suspected of being unsound or adulterated; to identify and name grasses, weeds and other plants; to identify insects and suggest measures for the control of such as are injurious, and to give advice concerning the prevention of the fungoid diseases which affect vegetation.

The Station is not prepared to furnish analyses of chemical or commercial fertilizers, as in Ohio that work is performed under direction of the Secretary of the State Board of Agriculture, at Columbus; but the Station will at all times respond to requests for advice concerning the use of such fertilizers.

The Station is not prepared to examine foods and dairy products suspected of adulteration, as that work is provided for in the Ohio Dairy and Food Commission, whose headquarters are at Columbus.

The Station is not at present prepared to offer advice or treatment for contagious animal diseases, but would refer all seeking such assistance to the Ohio Live Stock Commission, at Columbus.

Any citizen of Ohio has the right to apply to the Station for any information it can give, and all such applications will receive prompt attention.

Visitors to the Station are always welcome.

Address all communications to

EXPERIMENT STATION,
Wooster, Ohio.

REPORT OF THE BOARD OF CONTROL.

To His Excellency, ASA S. BUSHNELL, *Governor of Ohio:*

SIR: The Board of Control of the Ohio Agricultural Experiment Station submits herewith the annual report of the Station for the calendar year, 1895.

The reports of the officers of the Station will show that, notwithstanding the continued interruptions to the Station's legitimate work, incident to building and other improvements being made, it has yet accomplished much work of value to the agriculture of Ohio.

The history of the Chinch bug attack in 1895 in Central Ohio, and of the measures taken by the Station to meet it, illustrates the service which a body of trained experts may be able to render to the State at large in such emergencies.

IMPROVEMENTS.

The funds available this year from the appropriation made in 1894 have been expended in the completion of the improvements mentioned in our last annual report, the erection of a small dwelling for the foreman of the Horticultural Department, and in the beginning of the main or administration building, by the erection of a wing to be used as a chemical laboratory, mailing rooms, and rooms for photography. This wing is in the form of an L, 26x68x12x28. It is built of the gray sandstone found on the Station farm, in fire-proof construction. It will cost, when completed, about $15,000.

While this building will add much to the Station's facilities for work, it still leaves the general offices of the Station, its library and collections, unprovided for. It is earnestly hoped that an appropriation may be made for the completion of this building by the present General Assembly. After this is done the Station's demands upon the State treasury will be comparatively small.

As the Station is supported by the National Government, for the benefit of the people of Ohio, it would seem that the State cannot do less than to provide the necessary facilities for its work.

PERSONNEL.

At the beginning of the year Hon. J. H. Brigham resigned his position as member of the Board of Control, and Mr. J. T. Robinson, of Seneca county, was appointed in his place.

Col. Brigham was the author of the bill establishing the Station, and his connection with it has been a constant source of strength.

Mr. Edward Mohn was appointed Superintendent of the North-eastern Sub-Station, at Strongsville, Cuyahoga county.

Respectfully submitted,

R. H. Warder,
Secretary Board of Control.

REPORT OF THE TREASURER.

To Hon. S. H. Ellis, *President of the Board of Control:*

Sir: I respectfully submit herewith the financial report of this Station for the fiscal year ending June 30, 1895:

In statements A, B, C and D, respectively, will be found a record of the receipts and expenditures from the various funds; statement A being a statement of account with the annual appropriation received from the U. S. Treasury, and a copy of the report made to the Governor of the State and the Secretary of the U. S. Treasury; statement B showing the receipts from farm produce and other sales, and the expenditures from this fund; and statement C being statement of account with the State Treasury.

The three statements, A, B and C, are combined in statement D, which shows the total income and expenditures for the fiscal year.

STATEMENT A.

The Ohio Agricultural Experiment Station in Account with the United States Appropriation, 1894–95.

Dr.

To receipts from the Treasury of the United States as per appropriation for fiscal year ending June 30, 1895, as per Act of Congress approved March 2, 1887	$15,000 00

Cr.

By salaries	$10,267 50
Labor	3,156 37
Publications	136 32
Postage and stationery	201 80
Heat, light and water	247 25
Chemical supplies	41 33
Seeds, plants, and sundry supplies	280 96
Fertilizers	30 10
Feeding stuffs	283 24
Library	138 39
Tools, implements and machinery	96 99
Furniture and fixtures	36 50
Scientific apparatus	30 45
Traveling expenses	1 40
Contingent expenses	10 00
Building and repairs	41 40
Total	$15,000 00

I, the undersigned, duly appointed Auditor of the Corporation, do hereby certify that I have examined the books and accounts of the Ohio Agricultural Experiment Station for the fiscal year ending June 30, 1895; that I have found the same well kept and classified as above and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000 00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by me examined and found correct.

And I further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

{ SEAL OF INSTITUTION }
Signed,
S. H. ELLIS,
Auditor of Board of Control.

Attest. Chas. E. Thorne, *Custodian.*

I hereby certify that the foregoing statement of account to which this is attached, is a true copy from the books of account of the institution named.

PERCY A. HINMAN,
Treasurer of Board of Control.

STATEMENT B.

OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH PRODUCE FUND.

TO RECEIPTS.

Dr.

June 30, 1895, from sales of Agricultural produce	$1,061 91	
“ “ “ dairy produce	259 32	
“ “ “ live stock	1,001 96	
“ “ “ horticultural produce	1,485 72	
“ “ “ sub-station produce	43 34	
June 30, 1895, from labor	41 15	
“ “ rents	308 50	
“ “ miscellaneous sales	156 88	
Total receipts for the year		$4,358 78
To balance brought forward July 1, 1894		447 74
Total		$4,806 52

BY EXPENDITURES.

Cr.

June 30, 1895, for labor	$2,784 41	
“ “ postage and stationery	244 10	
“ “ freight and express	245 42	
“ “ heat, light and water	93 06	
“ “ chemical supplies	6 69	
“ “ seeds, plants and sundry supplies	384 60	
“ “ fertilizers	97 55	
“ “ feeding stuffs	274 98	
“ “ library	62 28	
“ “ tools, implements and machinery	50 45	
“ “ furniture and fixtures	6 50	
“ “ scientific apparatus	5 75	
“ “ live stock	469 37	
“ “ traveling expenses	106 23	
Total expenditures for the year		$4,795 39
By balance, carried forward		11 13
Total		$4,806 52

STATEMENT C.

OHIO AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE STATE TREASURY.

Date of appropriation.	Appropriation for—	Total amount to the station's credit.	Total amount expended.	Balance in treasury June 30, 1895.
1895	Expenses of Board of control	$500 00		$500 00
	Sub-station for field experiments	500 00	$319 77	180 23
	New construction	25 000 00	3 267 90	21 732 10
	Bulletin illustration	200 00		200 00
	Totals for 1895	$26,200 00	$3,587 67	$22,612 33
	Balance of appropriations for 1893 and 1894 brought forward July 1, 1894—			
1893	Expenses of Board of Control	175 40	175 40	
	Special work in Entomology	178 51	178 51	
	Live stock	2,058 21	2,058 21	
	Implements and farm machinery	330 19	330 19	
	Supplies	285 81	285 81	
1894	Expenses of Board of Control	400 00	124 33	275 67
	Sub-station for field experiments	803 26	803 26	
	Special work in Entomology	500 00	103 02	396 98
	New construction	15,000 00	15,000 00	
	Tool house	500 00	500 00	
	Telephone	200 00	200 00	
	Totals	$46,631 38	$23,346 40	$23,284 98

STATEMENT D.

TOTAL RECEIPTS AND EXPENDITURES OF THE OHIO AGRICULTURAL EXPERIMETN STATION FOR THE YEAR ENDING JUNE 30, 1895.

Receipts.

From U. S. Treasury	$15,000 00	
From State appropriations for 1895	26,200 00	
From farm produce, etc	4,358 78	
Total receipts for the year		$45,558 78
Total balance brought forward, July 1, 1894		20,879 12
Total		$66,437 90

Expenditures.

For salaries	$10,267 50	
Labor	5,940 78	
Publications	136 32	
Postage and stationery	445 90	
Freight and express	245 42	
Heat, light and water	340 31	
Chemical supplies	48 02	
Seeds, plants and sundry supplies	915 37	
Fertilizers	127 65	
Feeding stuffs	558 22	
Library	200 67	
Tools, implements and machinery	477 63	
Furniture and fixtures	43 00	
Scientific apparatus	36 20	
Live stock	2,527 58	
Sub-stations	1,123 03	
Traveling expenses	688 89	
Contingent expenses	210 00	
Building and repairs	18,809 30	
Total expenditures for the year		$43,141 79
By total balance carried forward		23,296 11
Total		$66,437 90

BUILDINGS AND IMPROVEMENTS

During the fiscal year the following amounts have been expended for permanent improvements on the farm:

New buildings	$17,016 33
Repairs on old buildings	1,751 57
Fruit tree planting	20 03
Miscellaneous improvements and repairs	41 40
Total	$18,829 33

PERCY A. HINMAN,
Treasurer.

REPORT OF THE DIRECTOR.

Hon. S. H. Ellis, *President of the Board of Control:*

Sir: The fourteenth annual report of the officers of the Ohio Agricultural Experiment Station is herewith submitted:

THE SEASON AND CROPS.

The season of 1895 began with a general and destructive drouth, the total rainfall at this Station for the months of February, March, April and May, being but 6.05 inches, against an average precipitation of 14.75 inches for these months for the seven years preceding. This period of drouth was concluded with a series of frosty nights, five heavy frosts being recorded between the 13th and 22d of May inclusive. These conditions were general over the State, and the result in Wayne county was a reduction of nearly one-half the yield of wheat from the average crop, and fully seventy-five per cent. of the yield of hay, the grass suffering from the frost even more severely than from the drouth.

The rainfall for the summer months was also below the normal, the total rainfall for June, July and August being 8.69 inches at this Station, against a seven-year average of 10.72 inches, so that neither oats, corn nor potatoes made a full crop on our upland soils, though corn on lowlands and in other sections of the State gave a large yield.

Apples in low lying orchards were generally destroyed by the frosts of May, but escaped at higher levels. The experimental orchard of the Station, which stands 200 feet or more above the Kilbuck and Apple Creek valleys, produced an enormous crop of fine fruit, while orchards a hundred feet lower produced nothing. The early drouth seemed to effectually check the apple scab, so that unsprayed fruit was as free from that fungus as that most carefully sprayed; but careful spraying with arsenical poisons produced a marked result in the freedom of the fruit from worms.

THE STATION'S WORK.

The legitimate work of the Station was considerably interfered with again in 1895 by the improvement work necessary to complete its equipment. This has especially delayed the publication of results, but it is hoped that these may soon be brought up to date.

The continued unfavorable seasons have materially affected the results of the Station's field experiments, both in variety testing and in the use of fertilizers. Such seasons emphasize the necessity for long continued observation in work of this character, and forcibly illustrate the futility of attempting to formulate a guide for actual farm practice upon the results of experiments conducted over a season or two only, or in pots or boxes, and under artificial conditions of temperature and moisture. Such experiments may have great value as studies in vegetable physiology, but the farmer wants to know what he may expect from a given process under the average conditions which prevail in his fields and under a fickle climate, and to obtain this knowledge the work must be carried on under natural conditions and through a considerable number of seasons. It is very true that such work is far more difficult to conduct than the pot experiment; that it is far more expensive, and involves an indefinite amount of patient labor, as well as technical skill of a degree not inferior to that required in the most elaborate pot tests; but the facts that it is practically impossible to so arrange the pot test as to permit the subsoil to exert its natural influence, and that it is impracticable to make such tests on a scale sufficient to overcome the errors due to individuality, are sufficient to relegate them to a secondary place, whether in the study of the soil or in that of the plant.

SUB-STATIONS.

The work with fertilizers, begun while the Station occupied the farm belonging to the State University, is continued under the management of the Station, through the coöperation of the Farm Department of the University.

A series of experiments in the continuous culture of corn, with and without fertilizers, begun by the Station in 1888 in Columbiana county, is still continued. The work at the Northwestern Sub-Station in Fulton county has now been in progress two years, and a "Northeastern" Sub-Station has been established near Strongsville, Cuyahoga county, on the heavy clay of that region. One hundred acres have been leased here, and several acres have been underdrained with lines of tile, laid thirty-six feet apart and about thirty inches deep, following the plan pursued at Columbus and at the Central Station, and corn and potatoes were grown with fertilizers in 1895. The results of all this work are being prepared for publication.

THE STATION'S PRINTING.

The State constitution provided that all printing of State publications shall be let by contract to the lowest bidder, and in the competition for this work a custom has become established of bidding for both printing and paper at prices far below those at which good work can be done or good paper furnished, with the expectation that inferior work and material will be accepted. The results of this system are exhibited in the bulletins of this Station, which have been printed on paper of the very cheapest quality and in typography which no first class publishing house would permit to go from its presses.

Under such conditions it is impossible to use illustrations of fine quality, since, when an illustration comes from the printing press a mere daub of black ink, its usefulness is gone

This explanation is rendered necessary because of the criticisms which are being made upon the paper and printing of the bulletins of this Station. The officers of the Station have no control over the quality, either of paper or printing, except by furnishing paper of better quality, and the past condition of the Station's finances has not permitted the large expenditure required for this purpose. It is hoped that an improvement may be made hereafter.

PUBLICATIONS FOR THE YEAR.

Eight bulletins of the regular series have been published during the year. A summary of their contents follows:

Bulletin 59, May, 1895, by A. D. Selby, Pp. 1–5.

Noxious weeds along thoroughfares and their destruction: A bulletin calling attention to the prevalence of weeds along roadsides in Ohio and the importance of these roadside weeds as seed distributors; giving the text of the Weed law of Ohio, and asking for cooperation of farmers and especially of roadmasters, superintendents and road supervisors in securing their destruction.

Bulletin 60, August, 1895, by C. E. Thorne and J. Fremont Hickman, Pp. 7–56.

Feeding for Beef, including experiments in feeding for beef and papers on the chemistry of cattle feeding and the comparative value of feeding stuffs.

The bulletin reports two experiments in feeding steers, conducted during the late winter and spring months of 1894 and 1895, in which a total of forty-seven three-year old cattle were fed for five months on rations of different composition. The meal ration for these cattle was based upon a mixture of equal parts corn meal and bran or wheat meal and bran, to which was added gluten meal or old process linseed oil-cake meal, for part of the cattle, the gluten meal or oil meal being used in small quantity at first, but gradually increasing until it composed one-fourth to one-third of the entire meal ration. The meal ration was gradually increased until the cattle were consuming twelve to sixteen pounds eac hper day. The rough feed given was corn silage, corn stover, and clover or timothy hay.

No strongly marked difference was found in productiveness between corn meal and wheat meal. Gluten meal appeared to be as productive, pound for pound, as old process oil meal, while its cost was considerably lower. The results reached from the addition of gluten meal or oil meal to the mixture of corn meal and bran were not conclusive. Corn silage was eaten with greater relish than dry cured corn fodder (stover). The average gain for the 47 cattle was 1.91 pound in live weight per day for 120 days, or 9.24 pounds for each hundred pounds of chemically dry substance consumed in the food.

Half the cattle were turned on grass early in May each year, but they made a smaller gain than those kept in the barn until the middle of June, though consuming nearly as much meal, being fed what they would eat night and morning. The food-cost of increase in each case was considerably more than covered by an advance of one cent a pound in value on the total live weight.

BULLETIN 61, SEPTEMBER, 1895, by W. J. GREEN and E. C. GREEN, Pp. 57–76; 4 Plates.

Sub-irrigation in the greenhouse : An illustrated description of the method of watering plants on greenhouse benches by sub-irrigation as developed by this Station.

Watering by sub-irrigation is more efficiently and cheaply done than by the ordinary method; sub-irrigated soil does not harden, but retains its original loose, friable condition, nor does it become mossy and water-logged. Plants are less liable to suffer from overwatering and disease than by surface watering, and in consequenee grow more vigorously.

The gain in weight of sub-irrigated lettuce over surface watered has been in some cases as high as 100 per cent., but in most of the experiments about 40 per cent. In one case the increase in the value of a single crop was sufficient to pay the cost of new bench bottoms, and in all cases the cost of reconstruction has been reimbursed the first season.

Tomatoes also showed a marked gain in crop by sub-irrigation.

BULLETIN 62, OCTOBER, 1895, by F. M. WEBSTER, Pp. 77–95; 1 Plate.

The grape-root worm : History, habits, natural enemies remedies and preventions of the Grape-root worm, *Fidia viticida*, Walsh.

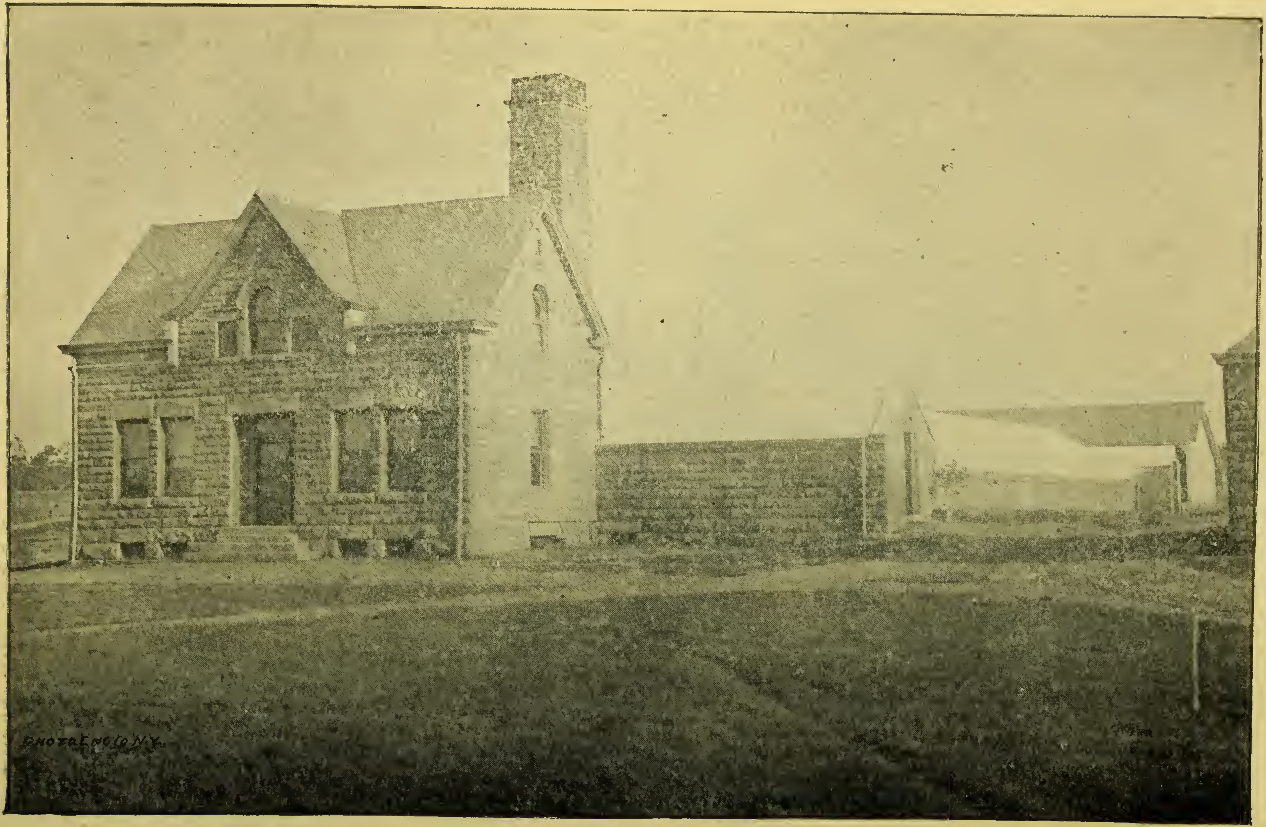
The Grape-root worm is the young of a small, brown beetle, that emerges from the ground, in the vicinity of Cleveland, Ohio, from the latter part of June until September, but largely during July, feeding on the leaves and depositing its eggs under the bark of the vines. These eggs hatch out minute worms, of a white color with brownish heads, which drop to the ground and make their way to the roots upon which they feed, when full grown constructing earthen cells in which the larger portion pass the winter, advancing to the pupal state in June without feeding in spring, the pupæ developing adults as stated above. There is but one annual brood. The natural enemies, so far as now known, attack the eggs only.

The beetles can be poisoned by very strong solutions of the arsenical poisons, and the worms can be killed with the fumes of bisulphide of carbon. Frequent stirring of the soil during July, and keeping a thick covering of mellow earth over the roots during this period, will also be of service in preventing the young from reaching the roots.

BULLETIN 63, NOVEMBER, 1895, by W. J. GREEN, Pp. 97–113.

Orchard Spraying and Notes of Varieties of Raspberries: A resume of recent progress in spraying, with directions for the work and list of varieties most benefitted by the operation. Sprayed trees have often yielded fruit when others were barren, or nearly so; it is advisable to spray young trees just planted, and all bearing fruit trees in all seasons, whether bearing fruit or not, as the scab fungus destroys foliage as well as fruit, and thus impairs the vitality of the tree. The varieties of apples most improved by spraying are Belmont, Benoni, Ben Davis, Early Harvest, Maiden's Blush, Newtown Pippin, Northern Spy, Rambo, Red Canada and Rome Beauty.

Baldwin, Grimes' Golden and Roxberry Russet have not shown much improvement under the treatment.



GREENHOUSES OF THE OHIO EXPERIMENT STATION.

Nearly all varieties of pears are improved by spraying, but not all to the same extent, while some are injured by late applications.

Bordeaux mixture is beneficial to plum trees, and the curculio may be held in check with Paris green, but the difficulty is increased in proportion as the plum trees are surrounded by other trees which harbor the curculio. At present it seems best to fight the curculio both by spraying and catching.

Peaches and American plums should be sprayed with half strength mixture, if applied when in leaf.

The most useful fungicide is the Bordeaux mixture, and in making it, an excess of lime is advised. Copper carbonate and potassium sulphid are useful in a limited way, to replace the Bordeaux mixture where it can not well be used.

Apple and pear trees should be sprayed with Bordeaux mixture twice before blooming, and once or twice after, according to variety, using six ounces of Paris green to a barrel of the mixture, the third and fourth times. Two more applications of Paris green, four ounces to the barrel, are advisable in some cases.

Three or four applications of Bordeaux mixture and Paris green are advised for plum trees, after blooming, using the curculio catcher still later.

Two sprayings, half strength, of Bordeaux mixture and Paris green combined, are advised for cherry trees, after blooming.

Grape vines require three or four sprayings with Bordeaux mixture; two before the fruit sets and two after; and two applications of copper carbonate still later.

Raspberry plants should be sprayed once before the leaves open, with Bordeaux mixture, and the young canes two or three times later, with the same, half strength.

Either Bordeaux mixture or potassium sulphid may be used for the mildew on gooseberry plants, and white hellebore for the currant worm.

A spray pump should have the parts with which the mixture comes in contact made of brass, or some material which will not corrode. The appliances needed for spraying large trees are about twenty-five feet of good rubber hose and ten feet of tubing, on the end of which the nozzle is fastened. A large air chamber is helpful, and some form of an agitator is necessary.

The most desirable new varieties of raspberries are Columbian, Eureka, Kansas, Lotta, Thompson and Early King. Gault, Mills' Nos. 7 and 15 require further trial.

All Seasons, Champion, Pride of Kent and Royal Church are not desirable.

Mohler is a synonym of the Eureka.

BULLETIN 64, DECEMBER, 1895, BY A. D. SELBY. Pp. 115–140; 1 Plate.

The Smut of Oats and its Prevention: An illustrated description of the smut of oats, with historical notes and a report of experiments in its control. The average loss to the oat crop of Ohio from smut is estimated approximately six per cent. These experiments show that this loss may be absolutely prevented by immersing the seed for fifteen minutes in water heated to a temperature of 133° F. or by soaking it twenty-four hours in a solution of potassium sulphid, made by dissolving one to two pounds of the salt in twenty-five gallons of water. This treatment not only prevents the smut, but also appears to increase the yield beyond the amount represented by mere smut prevention.

BULLETIN 65, DECEMBER, 1895, BY W. J. GREEN and H. O. MCFADDEN. Pp. 141–153.

Variety Trials of Potatoes: A comparative test of over seventy varieties of potatoes grown in 1895 at the Central Station, twenty-four of which were also planted at the North Eastern and North Western Sub-Stations, in Cuyahoga and Fulton counties.

The varieties which stood above the average in all cases are Sir William, Koshkonong, Columbus and Irish Daisy. Following closely are Forest Rose, World's Fair, Early Harvest, Carman No. 1, Nebula, Rural New Yorker No. 2, Timpee's No. 4, Early Norther, Victor Rose, Clay Rose and Maggie Murphy, in the order named. All of the varieties named are intermediate or late, except Early Harvest, Nebula and Early Norther. Everitt's Six Weeks, which is the same as the Early Ohio, is slightly earlier than these, and less prolific, while Salzer's Earliest, another name for Bliss' Triumph, is still less productive.

Trials made with second crop southern seed and late grown northern seed of the same varieties have shown no decided difference in yield nor in earliness from either seed.

BULLETIN 66, DECEMBER, 1895, BY C. A. PATTON. Pp. 161–171.

Meteorological summary and index.

Material for several other bulletins has been accumulated and is being prepared for publication.

PAST PUBLICATIONS.

In Bulletin 52 of this Station (twelfth annual report) is given a complete list of the publications of the Station up to the close of 1893, excepting certain circulars and newspaper bulletins, the substance of which is included in the regular bulletins, or annual reports. Since that date the following bulletins have been issued:

No. 53, March, 1894. Field experiments with commercial fertilizers.
No. 54, October, 1894. Strawberries.
No. 55, October, 1894. The Russian Thistle in Ohio.
No. 56, December, 1894. The San José Scale.
No. 57, December, 1894. Oats, variety and cultural experiments.
No. 58, December, 1894. Thirteenth annual report and Meteorological summary.
No. 59, May, 1895. Noxious weedes along thoroughfares and their destruction.
No. 60, August, 1895. Feeding for beef.
No. 61, September, 1895. Sub-irrigation in the green-house.
No. 62, October, 1895. The grape-root worm.
No. 63, November, 1895. Orchard spraying and notes on varieties of raspberries.
No. 64, December, 1895. The smut of oats.
No. 65, December, 1895. Variety trials with potatoes.
No. 66, December, 1895. Fourteenth annual report and Meteorological summary.

No addition has been made to the technical series of bulletins since No. 3, the contents of which were given in No. 52.

Twenty-two newspaper bulletins have been issued during the two years, raising the total number to 154. These bulletins are given to the general press in order that the general results of our investigations may have an earlier and wider publication than is possible through the regular bulletin alone.

ACKNOWLEDGMENTS.

The publishers of the following journals have aided the Station in its work during the year, either by republishing abstracts from its bulletins or by donating their publications to its library:

AGRICULTURAL PAPERS OF OHIO.

American Farmer, Springfield.
American Grange Bulletin, Cincinnati.
Farm and Fireside, Springfield.
Farmer's Home, Dayton.
Farm News, Springfield.
Gleanings in Bee Culture, Medina.
Ohio Farmer, Cleveland.

GENERAL PAPERS OF OHIO.

Alliance Review, Alliance.
Arcanum Enterprise, Arcanum.
Ashtabula News, Ashtabula.
Attica Journal, Attica.
Auglaize County Democrat, Wapakoneta.
Bakersville Press, Bakersville.
Barnesville Republican, Barnesville.
Cincinnati Price Current, Cincinnati.
Columbus Record, Columbus.
Cortland Herald, Cortland.
Crestline Advocate, Crestline.
De Graff Buckeye, De Graff.
Democratic Herald, Delaware.
Democratic Record, Chardon.
Forest Review, Forest.
Frederickstown Free Press, Frederickstown.
Fremont Journal, Fremont.
Geauga County Record, Chardon.
Geauga Leader, Burton.
Greenville Democrat, Greenville.
Herald, Middleport.
Industrial News, Toledo.
Jacksonian, Wooster.
Kenton Graphic News, Kenton.
Leader, Chillicothe.
Lodi Review, Lodi.
Malta Register, Malta.
Monroe Journal (German), Woodsfield.
New Concord Enterprise, New Concord.
Northern Ohio Journal, Painesville.
Ohio State Journal, Columbus.
Painesville Telegram, Painesville.

Plain City Dealer, Plain City.
Press, Columbus.
Salineville Banner, Salineville.
Shelby News, Shelby.
Tuscarawas Advocate, New Philadelphia.
Tuscarawas Chronicle, Uhrichsville and Dennison.
Union County Journal, Marysville.
Valley Enterprise, Milford.
Wayne County Democrat, Wooster.
Wayne County Herald, Wooster.
Wood County Democrat, Bowling Green.
Wooster Republican, Wooster.

PAPERS FROM OTHER STATES.

Agricultural.

Acker und Gartenbau Zeitung, Milwaukee, Wis.
Agricultural Epitomist, Indianapolis, Ind.
Agricultural Journal, Montgomery, Ala.
Agricultural Gazette, New South Wales.
Agricultural South, Atlanta, Ga.
American Agriculturist, New York, N. Y., and Columbus, O.
American Corn and Hay Journal, Sibley, Ill.
American Dairyman, N. Y. City.
American Gardening, New York, N. Y.
American Homestead, Omaha, Neb.
California Cultivator and Poultry Keeper, Los Angeles, Cal.
Canadian Entomologist, London, Ont., Canada.
Church and Farm, Salt Lake City, Utah.
Colman's Rural World, St. Louis, Mo.
Cultivator, Omaha, Neb.
Dakota Farmer, Huron, South Dakota.
Dorset Quarterly, Washington, Pa.
Elgin Dairy, Elgin, Ill.
Farm and Home, Springfield, Mass., and Chicago, Ill.
Farmers' Advocate, London and Winnepeg, Canada.
Farmer's Guide, Huntington, Ind.
Farmer's Magazine, Springfield, Ill.
Farm, Field and Fireside, Chicago, Ill.
Farm, Stock and Home, Minneapolis, Minn.
Florida Agriculturist, De Land, Fla.
Fruit Growers' Journal, Cobden, Ill.
Gardening, Chicago, Ill.
Grange Visitor, Lansing, Mich.
Green's Fruit Grower, Rochester, N. Y.
Hoard's Dairyman, Ft. Atkinson, Wis.
Home and Farm, Louisville, Ky.
Hospodar, Omaha, Neb.

Industrial American, Lexington, Ky.
Indiana Farmer, Indianapolis, Ind.
Iowa Homestead, Des Moines, Iowa.
Journal of Agriculture, St. Louis, Mo.
Maritime Agriculturist, St. John, N. B.
Mirror and Farmer, Manchester, N. H.
National Stockman and Farmer, Pittsburg, Pa.
Orange Judd Farmer, Chicago, Ill.
Oregon Agriculturist, Portland, Oregon.
Pacific Rural Press, San Francisco, Cal.
Pacific West Dairyman, Tacoma, Wash.
Practical Farmer, Philadelphia, Pa.
Prairie Farmer, Chicago, Ill.
Rural New Yorker, New York, N. Y.
Rural Northwest, Portland, Oregon.
Southern Cultivator and Dixie Farmer, Atlanta, Ga.
Southern Planter, Richmond, Va.
Southern States, Baltimore, Md.
Stock and Farm, Bunker Hill, Ind.
Successful Farmer, Sioux Falls, S. D.
Sugar Beet, Philadelphia, Pa.
Wallace's Farmer and Dairyman, Ames, Iowa.
Weather and Crops, Chicago, Ill.
Weekly Globe and Canadian Farmer, Toronto, Canada.
Western Breeder, St. Joseph, Mo.
Western Farmer and Stockman, Sioux City, Iowa.
Western Resources, Lincoln, Neb.
Western Soil Culture, Sioux City, Iowa.
Western Swineherd, Geneseo, Ill.
Wisconsin Farmer, Madison, Wis.

General.

Baltimore Weekly Sun, Baltimore, Md.
Clover Leaf, South Bend, Ind.
Detroit Free Press, Weekly, Detroit, Mich.
Kansas Weekly Capital and Farm Journal, Topeka, Kansas.
National Provisioner, New York, N. Y.
Press, The Weekly, New York, N. Y.
Press, The Weekly, Philadelphia, Pa.
University Record, Ann Arbor, Mich.
Union, The Weekly, Manchester, N. H.
World, The Weekly, New York, N. Y.

IMPLEMENTS, SEEDS AND PLANTS RECEIVED.

Thanks are returned for the following donations to the Station :

HORTICULTURAL DEPARTMENT.

Ayer, O. H., Lawrence, Kansas, cions of Bennie pear.
Allen, W. F. Jr., Salisbury, Md., 12 Allen strawberry plants.
Bennett, L. W., Freeport, O., 1 variety of strawberry.
Brackett, G. C., Lawrence, Kan., 1 variety of blackberry.
Benay, Ran., New Cumberland, Ind., 2 varieties of strawberries.
Baker, J. Q., Lebanon, O., 1 variety of strawberry.
Bovee, Marvin, Northville, Mich., 1 variety of potato.
Buckbee, H. W., several varieties of garden seeds.
Coote, Prof. George, Corvallis, Oregon, raspberry and blackberry plants.
Crawford, M., Cuyahoga Falls, O., Margaret strawberry plants.
Clark, M. W., Kent., O., 2 varieties of strawberry.
Cushman Gladiolus Co., Euclid, O., Gladiolus corms.
DeMuth, P. R., Connellsville, Pa., 1 variety of grape.
Dinsmore, John, Fernwood, O., apple cions.
Department of Agriculture, Washington, D. C., apple, pear and cherry cions.
Earhart, W. H., Lexington, O, strawberry and blackberry plants.
Frantz, E. E., New Carlisle, O., 1 variety of raspberry plants.
Carvin, D. B. & Son, Wheeling, West Va., 1 variety of strawberry plants.
Green, Chas. A., Rochester, N. Y., 1 plant Red Cross currant.
Hendershon, Jas. A., Marietta, O., Marietta strawberry plants.
Harvey, R. R., Carrollton, O., 1 gooseberry plant.
Hallberg, George, Brooklyn, N. Y., cauliflower seed.
Hall, M. C, Freedom Station, O., tomato seed.
Hoover & Moore, Antlers, Colo., tomato seed.
Kinney, W R, Portsmouth, O., Epworth blackberry plants.
Lee, H S. & A. J., Geneva, Pa., 3 varieties of strawberry plants.
Lehman, S. J. & Co., Enon, O., 1 variety of strawberry plants.
Maule, Wm. H, Phila., Pa., No. 17 potato.
Mast, H. E. & A. E., Millersburg, O., Mast strawberry plants.
Maynard, C. C., Kincaid, Kansas, Maynard dewberry plants.
Mohler, D. M., New Paris, O., 2 varieties of raspberries.
Munson, T. V., Denison, Texas, 8 varieties of grapes.
Pratt, C. S., Reading, Mass., 2 varieties of strawberries.
Rice, A. F., Griswoldville, Ga, 1 vine Superb grape.
Rane, Prof. W. F., Morgantown, West Va., tomato seed.
Street, I. F., West Middleton, Ind., 1 variety of raspberry.
Storrs & Harrison Co., Painesville, O., 1 Carman gooseberry plant.
Schorg, A. J., Hibbitts, O., 1 variety of strawberry.
Shively, M. J., Frankfort, O., 1 variety of raspberry.
Thompson, W. S., Rio Vista, Va., Carrie strawberry plants.
Tubbs, John, Glen Burnie, Md., Tubbs strawberry plants.
Van Orman, F. B., Lewis, Iowa, No. 99 potato.
Wood, A. L., Rochester, N. Y., 6 Pearl gooseberry plants.

Wolfgang, Harry, Leetonia, O., Lady Franklin strawberry plants and one variety of potato.

Weltz, James, Lucas, O., apple cions.

Young, Fred. E., Rochester, N. Y., 1 Bourgeat quince, 1 Walter Pease apple tree.

Witterstatter, Sedamsville, Cincinnati, O., 3 varieties carnations.

AGRICULTURAL DEPARTMENT.

Dana, C. H., West Lebanon, N. H., 25 ear markers.

German Kali Works, 93–99 Nassau St., N. Y. City, 600 pounds muriate of potash and various publications.

Kelley, C. E., Newark, N. Y., 10 pounds seed wheat.

Lawhead, G. W., Zanesville, O., 1 bushel seed oats.

Perkins, C. S., Weymouth, O., 1 peck seed oats.

Saunders, Wm., Ottawa, Can., 2 packages barley and 2 packages spring wheat.

Scott, Walter, Hoosic Falls, N. Y., 1 cow stanchion.

Respectfully submitted,

CHAS. E. THORNE,
Director.

REPORT OF THE HORTICULTURIST.

W. J. Green.

The work in the horticultural department has progressed satisfactorily during the year except in a few cases where frosts and dry weather injured or destroyed the crops.

The strawberry crop suffered most, the failure being complete with some varieties. This made a report on the crop impossible, and has been a source of considerable disappointment to many who are awaiting the results with new varieties.

All other small fruits, except raspberries, fared in the same manner.

A report on varieties of raspberries has been published as a part of bulletin 63, the other portion being devoted to the topic of spraying fruit trees.

Previous editions of bulletins on spraying having become exhausted this was prepared to meet the demands which are likely to occur, as the season for spraying approaches. Although the matter is not entirely new, many facts are presented which have not been published before. The season of 1895 being very dry, the apple scab did not develop as usual In fact it was difficult to find any evidence of it at any time during the season, hence spraying had no appreciable effect. It seems quite probable that this disease will hardly get a foothold early enough next season to do much harm, but it does not follow that efforts to combat it should be relinquished. The present condition affords a good opportunity to hold the disease in check and to prevent its appearance again, to a harmful extent.

This point is dwelt upon in the bulletin referred to, and it is believed that if the recommendations are carried out the work will prove easier and more effective than has been the case in the past.

The importance of spraying young trees is also urged, beginning as soon as they are planted, and continuing as long as they are worth caring for.

Quite extensive experiments with potatoes have been carried on during the season, along the same lines as in former years, both with varieties and fertilizers.

The aim with varieties has been not to include a great number, but some of the best old sorts and all of the new. More space has been given each variety than is customary, and all are duplicated, as far as possible.

Fertilizer experiments with potatoes are carried on in the same manner as with other crops, except that the rotation is somewhat different. Bulletin 65 gives the results in detail with varieties during three seasons at the central station and one at the branch stations; with fertilizers two seasons at the central station and Northwest Sub-Station and one at the Northeast Sub-Station.

The fruit trees which have been planted have made a healthy growth and are in excellent condition. Many new varieties were added last spring, especially of plums, and the collections are now up to date and fairly complete. The soil in the fields set aside for this work is very satisfactory, and has even surpassed expectations. The location, as to altitude and freedom from frost, could hardly be bettered.

Considerable improvements have been made on the barn during the year. The work of replacing the old siding with new and painting has been finished. A cold storage room was fitted up in the basement of the barn in 1894, and proved to be satisfactory, but a few changes were found to be necessary in order to make it rat proof, and in addition a frost-proof storage room was completed alongside. These rooms are designed for the purpose of keeping fruits and vegetables beyond the ordinary period, but more particularly for the purpose of experimenting in methods of preservation and of answering the question: "Will it pay fruit growers and farmers to provide such rooms?" A dwelling house for the foreman has been erected near the orchard, and the one which was on the place, when purchased, is to be repaired.

In the green-houses the principal work accomplished has been the completion of some experiments with sub-irrigation. A bulletin treating of lettuce, grown by this method, has been published, and the results with tomatoes are now ready for publication.

The experiments with roses have been sadly interfered with because of nematodes. With carnations the results have not been obscured in this manner, and it is possible that they will be ready for publication during the year. This method of watering has been so satisfactory thus far that the best course to pursue seems to be, to continue the work and to show the applicability of the method to the fullest extent possible. The Assistant Horticulturist has carried on considerable work in crossing fruits and vegetables, the results of which will not be apparent for some time.

Ever since the organization of the Station there has been a demand for horticultural literature, dealing with methods and well known facts. Primary instruction in horticulture has been eagerly sought, and bulletins giving instruction in the various lines of fruit and vegetable culture have been asked for freqently. This demand has grown perceptibly of late, and some preparation, in the way of laying plans, has been made to meet it. It may be truthfully said that the work of preparation has gone farther than the laying of plans, for the horticultural plant, as now established, can be used to furnish material for illustration, along with facts of the same kind from other sources. It is probable that one or more bulletins of this kind will be issued during the year.

REPORT OF THE AGRICULTURIST.

J. Fremont Hickman.

Field and feeding experiments, with minor branches of the main work which naturally follow, constitute the major portion of the work of this department. Our variety tests with grains, more fully explained in previous reports, instead of including an irregular and indefinite number of so-called sorts, have been restricted to not more than sixty varieties of corn, oats or wheat. In these tests it is the intention, if possible, to include all new varieties, and grow none less than three years, and but few more than ten, except a few varieties that are grown continuously as standards for comparison.

Cultural tests have been continued with wheat and oats, including deep and shallow seeding, loose and compact seed beds, drilling and broadcasting, thick and thin seeding, and with wheat, early, ordinary and late seeding, also in the case of oats grown after corn, a comparison of surface stirring with plowing for a seed bed and comparing results from same plats in the following wheat crop.

Cultural work with corn has been continued as follows: growing corn continuously from butt, tip and middle grains; thick, as compared with thin seeding, or hilling against drilling; deep and shallow cultivation; the comparison of yields from tracts of equal size of corn cut and corn left standing on stalk; the effect of manure on corn ground, as applied direct from the stable during the winter, or hauled from the barnyard just before plowing.

Experiments with forage and silage crops have been continued on a larger scale than in previous years. The list under cultivation, during the season of 1895, included the following: Oats and crimson clover; cow peas; Canada field peas; Alfalfa; two varieties of Soy beans; two varieties of vetches; flat pea (Lathyrus sylvestrius); Sacaline; Rape; red and white Kaffir corn; Jerusalem corn; Millo Maize; Hungarian grass; four varieties of Millet, and ensilage corn.

EXPERIMENTS WITH COMMERCIAL FERTILIZERS.

This line of work, now fully started at this Station and in charge of this department, includes thirty plots in corn, oats and wheat continuously; ninety plots in a short rotation, including potatoes, wheat and clover, (the potato division in charge of the Horticultural department) thirty plots in each crop; one hundred and fifty plots in a five year rotation, including corn, oats, clover, wheat and timothy. The work at the Ohio State University includes a series of one hundred and one plots—sixty-six under continuous cultivation, one-third, or twenty-two plots, in corn, one-third in oats and one-third in wheat. The other thirty-five are in crop rotation, similar to the five year rotation on the Station farm, except that it is on a smaller scale. The experiment in Columbiana county includes fourteen plots under cultivation, on which corn is grown continuously; eight crops have now been harvested, the last two of which have had double the amount of fertilizer used upon any of our other field tests of the same dimensions.

DEHORNINC AND FEEDING EXPERIMENTS.

During the year, sixteen steers were dehorned. In this work four sets were taken off with the saw, the other twelve with the Keystone Clippers.

With six of these steers extra care was taken to fill the cavity of the stub horn with oakum, saturated with a weak solution of carbolic acid, and over this a bandage of muslin was secured by fastening under the throat. Six others were treated with the oakum and acid but left without the bandage. The other four were given no attention after the horns were clipped off.

The herd after dehorning was turned out together and all treated alike for the five weeks following. No experiments of any kind were conducted to show variations from the different methods of dehorning, except mere observation, which seemed to justify the following opinions:

1st. That the cattle dehorned with the saw suffered more than those that were dehorned with the clippers; possibly not more in the same length of time but certainly as much for a period of time almost twice as long as those taken off with clippers.

2nd. The saw did a little smoother job than the clippers, but there was so little difference in the appearance of the stubs that only an expert would be able to tell by which implement the dehorning had been done.

3rd. The animals not treated after dehorning apparently did as well as those that were given all possible protection, but the sores did not heal quite so rapidly.

4th. The extra care of bandaging the stubs did not seem to be of any marked advantage, but the application of oakum and the solution of carbolic acid was, I believe, well worth the trouble of applying.

5th. Incidentally, it is worth while to mention that one of these sixteen steers died four weeks after dehorning; indirectly a result of dehorning, but directly caused by over exertion in a scramble for supremacy, in which the bleeding from the horn cutting was opened afresh, from which the animal bled to death, though every known means were used to stop it.

These steers were put into a feeding experiment January 1, 1895 and fed until the middle of June, when they were shipped to Pittsburgh and sold in the market. This experiment had for its object the study of the relative value of different feeds as meat producers and such other points as were suggested in the work as it proceeded. A full discusion of this experiment is given in bulletin No. 60 of this Station. The following feeds were used: Gluten meal, wheat meal, corn meal, wheat bran, corn silage, corn stover, clover and timothy hay.

THE DAIRY.

The six breeds of cows, named in the annual report for 1894, have been under test the entire year. The number of pounds of each kind of feed eaten by each animal has been carefully recorded, and the number of pounds of milk given, and the cows have been weighed at least three times each month on consecutive days.

The creamery was ready for use June 1, 1895. Previous to that date each mess of milk was weighed, sampled for analysis on the Babcock tester and the milk sold at the Wooster creamery. Since that date it has been weighed, sampled and analyzed as before, and the milk of each breed manipulated for butter separately, showing the per cent. of fat produced by each cow and the amount of butter made from each breed.

Other important data are being collected, such as the churnability of milk and the solidity of the butter of the separate breeds.

Mr. Willis G. Harry has full charge of all the details of handling milk and making the butter, and for this work all credit is due him.

The breed test includes the increase of the herds. In this the calves are taken at three days old and fed by hand. The feed, of whatever kind given, is weighed and recorded for the purpose of showing what it costs in the different breeds to produce a yearling, a two-year-old or three-year-old steer ready for the block or a heifer with her first calf. The original dairy herds aggregated twenty-three animals, seventeen cows and six bulls. We have added two grade cows to these and with the increase we now have fifty-three head of cattle in our barns.

SHEEP FLOCKS.

For want of room it was found impracticable to undertake feeding experiments with the breeds of sheep previous to the opening of the present winter. The wool of the several breeds was weighed at shearing time and laid away for later weighing to test shrinkage. Some two months ago it was placed in the hands of Justice, Bateman & Co., Philadelphia, Pa., to be sold on its merit and relative values reported. From the forty ewes, forty lambs were raised up to weaning time, since which one was killed by dogs, and six have died from disease. At the present time the several breeds are being fed separately, all feed consumed and all refused is weighed and record preserved.

FARM PRODUCTS.

The table below shows the area of land occupied by the several crops in 1895, the total and average yield per acre, and the price of the several products in the Wooster market at the close of the year.

Crops.	Acres.	Total produce.	Yield per acre	Market price.
Wheat	41.5	410 bushels	1.01 bushels	$0 52
Wheat straw	41.5	16.2 tons.	0.39 tons	6 00
Oats	32	1,376 bushels	43 bushels	0 28
Oats straw	32	22 7 tons	0.70 tons	6 00
Corn	32	1,184 bushels	37 bushels	0 28
Corn stover	32	42.88 tons	1.34 tons	3 00
Ensilage corn	11	135 tons	12.26 tons	
Hay timothy	96	771 tons	0.74 tons	12 00
Hay clover	8	5.006 tons	0.62 “	11 00
Millet	22	32.5 tons	1.47 “	

All of the above produce was actually and carefully weighed except about ten acres of the hay and sixteen acres of the stover, for these the average of the other acres in the same crop was taken as the basis for estimating. The very low yield of wheat and hay was due to the frost of the middle of May and to dry weather before and after. The yield of millet per acre is hardly a fair representation, for the reason that more than half the entire crop came off about six acres of ground.

MISCELLANEOUS.

During the summer and fall months a large share of my time has been given to superintending various improvements on the farm, among which may be named the completion of the stabling in the new barn, including grout and cement flooring, stalling and a liquid manure cistern; outside grading approaches; building yard and lane fences; and putting in three sets of stock scales, two of these at the new barn and one at the horse barn. The two small dwellings, remodeled last year, have each had fenced off with them about three-fourths of an acre of land; the same area has been set apart for each of the other two laborer's dwellings. On all four a part has been set off for lawn and a part for garden, a portion is set to fruit trees and grape vines of various kinds and the balance is fenced separately for chicken runs with poultry houses included. Various other minor improvements have been made in order to make these dwellings comfortable.

Some time has been given to the grading and improvement of roads and drives and filling of washes on the cultivated land, caused by the unprecedented rain of September 12, on which date 3.28 inches fell between 2 and 9 P. M.

During the year four weeks of my time was given to institute work, outside of preparation, and nearly three weeks to the testing of dairy cows, a part of this for a county institution, a part for the State Dairy test, and a part for the National Holstein Freisian Association. In all twenty-seven cows were tested.

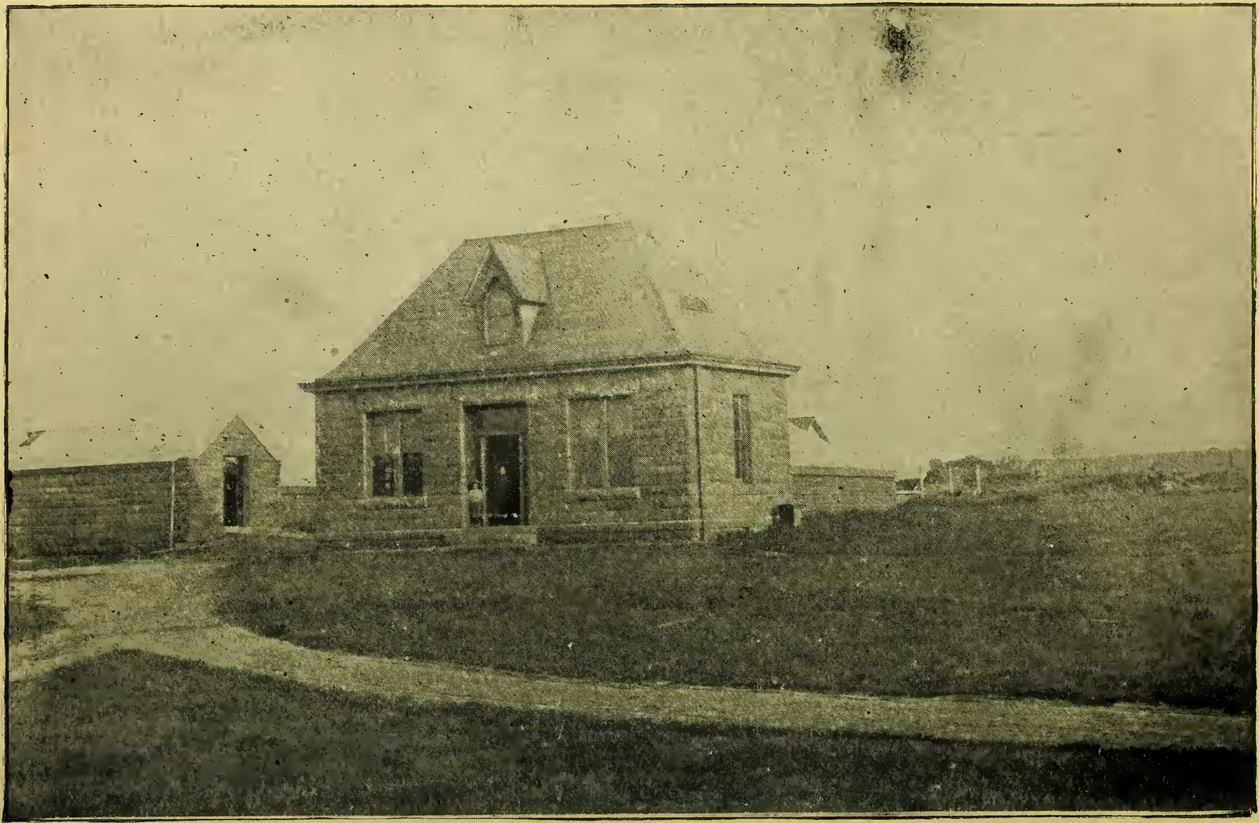
REPORT OF THE ENTOMOLOGIST.

F. M. Webster.

The condition of my department is the same as represented in my last annual report, nor can an improvement be expected until a better support can be afforded. An assistant was provided for two months, at a time when we were in the midst of the distribution of the chinch bug fungus and consequently overwhelmed with correspondence relative thereto. This assistant was, however, paid from the fund for special work in entomology, and was discharged as soon as this work was practically ended for the summer.

During the year, over 1,400 letters and postal cards relating to insects and requiring a more or less extended reply, have either been received by me, or have been referred to this department. The field investigations during eleven months have required fifty-five days of my time, and I have in that time traveled over 7,000 miles in order to carry them out. Besides this, fully one month has been spent in institute work and attending agricultural and horticultural gatherings that I was invited to address.

The San José Scale has been carefully watched wherever it is known to occur in the State, each infested orchard being visited as often as seemed necessary, and the owners given all information and instructions possible to enable them to keep the pest under control and stamp it out. The advance eastward of the corn root worm has been carefully followed throughout the entire length of the State, and farmers warned of its approach and informed how to escape its ravages. Over 650 packages of the chinch bug fungus, *Sporotrichum*, were distributed to farmers of the State, where the outbreak occurred. The northward spread of the Harlequin cabbage bug, a native of Mexico, but just now entering extreme southern Ohio, has and is being carefully watched and instructions as how best to fight it given to truck farmers and others within the area over which it is known to occur. The same is true of the Basket worm, which appears to be working its way northward. What for a time bid fair to be a serious outbreak of the plum scale, in Ottawa county, was prevented by the timely use of kerosene emulsion and to the good offices of beneficial parasites. A more or less extended investigation was made of the outbreak of the western striped cut worm, *Feltia herilis*, and the several species of webworms, *Crambus*, which ravaged the grain fields, planted on sod in spring. As this required a simultaneous study in the field and laboratory



BIOLOGICAL LABORATORY, OHIO EXPERIMENT STATION.

little could be done for lack of trained assistance. For lack of time to carry it farther, the investigation of the grape root worm, among the vineyards in the Euclid district, was necessarily abandoned. This was also true of the onion Thrips, *Thrips tritici tabaci*, which causes the white blast in onions. An investigation of the black aphis of the peach has been undertaken, with a view of destroying the pests on the roots of young peach trees, where they seriously affect the health of the tree. It is hoped that this can be done practically and effectually by the use of carbon bisulphide, but to demonstrate this, will require both study and field experimentation. There is great necessity for a study of the insect enemies of the peach, in Ohio, and I shall be more than pleased to do this, as soon as proper facilities and assistance is afforded me. But to undertake this work under present existing conditions, means the abandoning of other work, equally or more imperitive.

One bulletin has been prepared and printed on the grape root worm. A second of about forty pages is ready for the printer, and a third, on the chinch bug, is in course of preparation.

The work of this department has grown until the services of a thoroughly skilled assistant is a necessity; unskilled assistance will not fill the requirements and will be practically useless. What the situation demands is an assistant, sufficiently trained in entomology as to be able to follow investigations under the direction of the entomologist, both in the laboratory and field; give advice in regard to the common pests of the orchard, garden and field, when called upon to do so in the absence of the entomologist. At present, almost without exception the books required in the work of my department are my private property, many of them having been purchased while in the employ of the Station and at my own expense. I consider that I am justified in retaining these in my own library, but use them in my work. Their use requires me to do all of my writing at my house, thus necessitating my absence from the Station, and preventing my following laboratory investigations or meeting, personally, people who visit the Station and wish information regarding insects. A working library at the Station is therefor necessary, which, with an assistant as above described, will double the usefulness of my department.

REPORT OF THE BOTANIST.

AUGUSTINE D. SELBY, B. SC.

During the year just closed greater convenience was secured by removal to the Station grounds and the location of the office of the department adjacent to the Botanist's greenhouse. This change has been without drawbacks, and is heartily welcomed. The department is still crowded and limited in various ways, in so far as in-door accommodations go, but the larger laboratory represented by the growing plants of the State has offered a profusion of inviting opportunities. The effort has been to take up certain promising lines of investigation and to carry these forward in every way possible, while not neglecting the constant inquiries which have been received concerning plant diseases and weeds. Some important, though by no means final additions to equipment for microscopic investigation were made and additional works of reference have also been received.

The study of plant diseases has occupied the larger share of attention, and weed investigation a second place as to time and effort expended.

PEACH DISEASES.

The study of peach diseases has been continued, although with efforts largely confined to the Lake district, the only one where a fair crop of fruit was realized. It was expected to extend the work the past year to the other peach regions but the loss of the fruit crop and limited resources at command indicated the procedure stated. The investigations made in this line during the year pertained to peach leaf curl, yellows, peach fruit spots, peach rot, root or crown gall of peach, and to an obscure twig spot. Incidentally, the occurrence of the root aphis, *Aphis persicæn iger* Smith, was disclosed, although the study of the pest falls without the Botanical Department.

Spraying has been found practicable, even upon the tender foliage of the peach, and for this purpose the use of a 150 gallon formula of Bordeaux mixture in later sprayings (two pounds of copper sulphate and two pounds of lime to fifty gallons of water), is recommended; the seventy-five gallon formula (4 pounds each of lime and copper sulphate to fifty gallons water) may be safely employed before growth begins in the spring.

Leaf curl prevailed only to a limited extent, while fruit spots have been of more than usual abundance. A spot of the peach heretofore not observed in Ohio, disfigured the fruit in two sections of the Peninsula and Island district; this is designated as the brown or pustular spot. Spraying experiments with this disease, which is due to the work of a fungus, showed a prevention amounting to 73 per cent. of the spotted fruit. In some cases the spotted fruit on untreated trees reached 34 per cent. of the crop. The experiments in spraying conducted by the Station Botanist were chiefly in the orchards of William Miller of Gypsum, Ottawa county.

Some peach trees offered for delivery by a nurseryman outside the State were found to be badly affected with root galls. The same trouble has been under examination upon bearing trees. The excrescences, which are from $\frac{3}{4}$ inches to 2 inches in diameter, appear to be of the same sort known as crown gall on the Pacific slope.[1] It would seem that we have in this disease a serious affection of the peach. Purchasers of trees can not exercise too much care with respect to trees with crown gall; such trees are fit only for the brush pile. A similar affection of grapes also occurs.

PEACH YELLOWS.

The operation of the statute pertaining to Black Knot and Yellows, and the investigation of peach troubles, have disclosed the actual occurrence and present distribution of peach yellows in Ohio. The contemplated study of this destructive disease does not include an examination into its cause, nor original experiments for its cure, beyond removal and burning of diseased trees; both of these questions have been ably studied by a special agent of the United States Department of Agriculture, and the results published. The exact cause of peach yellows is not known, nor is there a cure for trees affected with the disease. The orchardist who would check its spread must learn to recognize the unfailing symptoms of yellows and apply the axe and fire to the prompt destruction of affected trees. Promptness is of great value in this preventive means of check; the disease is undoubtedly contagious, and spreads from the affected trees to healthy ones. It is better to burn the removed trees as near as possible to the place of removal, since dragging these through the orchard appears to carry the infection. Yellows prevails to a greater or less extent in at least four counties, namely: Lake, Erie, Sandusky, and Ottawa. The relative spread in the several districts where it is known to occur may be seen by reference to the map (Map 1) here published.

That the advent of the yellows means the serious decline of Ohio peach orchards is not held by the writer. The history of the peach industry in certain districts of Michigan, where yellows has been known for years, offers proof that this fruit may be grown successfully in the presence of this disease. The proper attitude toward yellows appears to be that of early recognition, ready admission of its occurrence in the locality it may enter, and with all this *prompt removal of affected trees* The detailed descriptions and investigations upon diseases of the peach will be published shortly in a bulletin now in preparation, and devoted to that subject.

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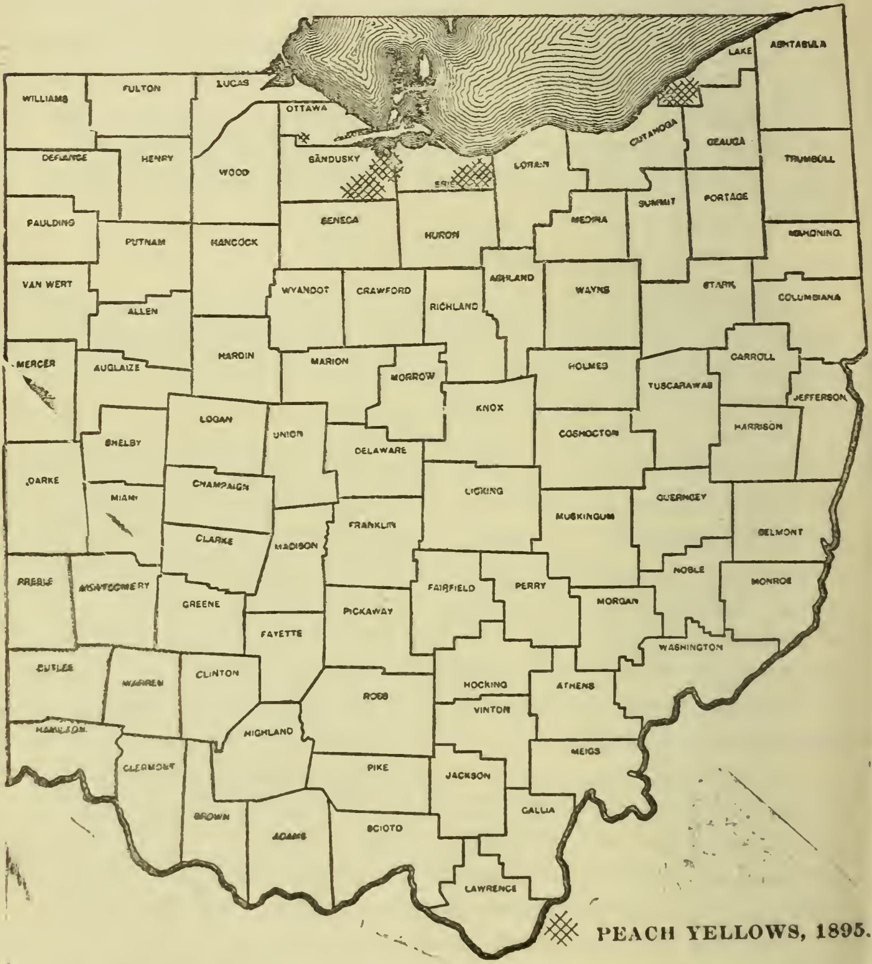
[1] **Woodworth, C. W., Bulletin 99, Cal. Exp. Sta., 1892, Tuomey, Jas. W., Bulletin 1, S. II., Arizona Exp. Sta., 1894, and Smith E. F., Jour. Myc. VII p. 376, 1894.**

MAP I.



Showing Known Distribution of Peach Yellows in Ohio, in 1895.

THE BLACK KNOT-YELLOWS LAW.

However, lest the full report be delayed in printing, some references to the operation of the statute upon Black Knot and Yellows are added: In the districts where fruit growing, especially the growing of plums, cherries and peaches, is a large factor in general culture, the free-holders have put the law into operation or have taken the steps required of them for this purpose. There is great local variation in the results attained, and there appear to be certain inadequacies in the statute, which are the subject of frequent suggestion. One correspondent states that the Township Trustees reminded him of their option as to the appointment of the Fruit Commissioners. The law states that they (the Trustees) "may elect" etc., and it is believed to be a rare occurrence that the Trustees will decline to make the selection of Commissioners; nevertheless this option as to choosing the Board of Fruit Commissioners, after a petition has been presented, is urged by many as an objection. The serious drawback in some instances has been the insufficient pay ($1.00 per diem) allowed the members of the Board for services rendered. Township Trustees in certain instances have made many selections without securing three persons who were willing to serve.

This question of insufficient remuneration is offset by manifest advantages to the fruit grower who serves in such capacity, yet it is a serious defect and one which impedes the progress of measures for the suppression of diseases in plants. A more serious difficulty even has been that of securing persons familar with yellows. It is here that the good offices of the Station have been invoked. It would appear that provision for securing expert advice, upon yellows particularly, to aid the Board of Fruit Commissioners in forming judgment, would be a useful amendment. The Station Botanist has already visited two townships where yellows prevail, in consultation with the Fruit Commissioners and assurances are given that good came of the visits.

GRAIN SMUTS.

The smuts of grain, common and well known fungous diseases, have been investigated in a preliminary way, during the year. The results of studies and experiments on oat-smut have been embodied in Bulletin 64. Experiments to test methods of prevention for both loose and stinking smuts of wheat, have been inaugurated, and some trial made with respect to prevention of corn smut.

Oat-smut prevailed to an unusual degree upon the Station grounds in 1895, thus furnishing a severe test of methods of seed treatment. Without entering upon detailed discussion, it may be stated that treatment of the seed oats before sowing is successful in smut prevention. Either of two methods may be employed: (1) Immersing the seed oats for fifteen minutes in hot water at a temperature of 133° F., or (2,) soaking the seed for twenty-four hours in a three-fourths per cent. solution of potassium sulphid (liver of sulphur) made by dissolving one and one-half pounds of the fused sulphid in twenty-five gallons of water. In both cases the seed must be spread and dried before sowing. This seed treatment not only prevents the smut but increases the yield beyond the amount necessary to replace smutted heads with sound ones. This net increase the present season is at the rate of about two and one-half bushels per acre, an increase greatly beyond the cost of seed treatment. The loss from oat-smut in the State in 1895 is estimated at six per cent. of the crop. The estimated crop for 1895 is 32,000,000 bushels, with a value of $8,000,000. Six per cent. of this amount indicates a yearly loss of $480,000 through oat-smut alone; the entire loss is preventible as shown.

Loose smut of wheat, the one noticeable at the blossoming period, and which converts the entire spike or head into a dirty mass of spores, prevailed to the usual degree. It is estimated that one-half per cent. will about cover the loss from the loose smut, that is, one head in 200 is lost thereby. The stinking smut, which attacks the kernels, was noted in fields near the Station grounds. Counts made by the Botanical Department in one of these, through the kind permission of the grower, showed thirty-seven per cent. of heads smutted. So great a proportion is not general, but local losses of this amount, through stinking smut in wheat, are occasional. It has been shown by this Station [2] that the stinking smut is preventible through seed treatment. No statement can at present be made as to the success of treatment of the seed grain to prevent loose smut in wheat. The results in this line will be published when reached. The average losses from both the loose and stinking smuts of wheat can scarcely fall below one per cent. of the crop. The average wheat crop is 45,000,000 bushels annually, and one per cent. of this gives 450,000 bushels loss through smuts in wheat. Put into dollars, the loss becomes $270,000 for each year. A bulletin upon wheat smuts and methods of prevention, is contemplated for 1896.

Barley is not grown extensively in the State, although the annual product reaches from one-half to three-quarters of a million bushels. The loose smut of this cereal is reported by a grower in Clarke county, as affecting one to two per cent. of the heads, and five per cent. was found in a small plot of "Trooper" (spring sown) on the Station grounds.

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[2] Hickman, J. F., Bulletin, Vol. IV, No. 4, 1891, pp. 81-86.

Jensen[3] has shown that the barley smuts are likewise prevented by the hot water treatment with special modifications.

Corn smut has occupied the attention of farmers more and more in the past few seasons. The work of Brefeld[4] pointing out the essential difference in smut infection in corn from that demonstrated for wheat and oats, has left this disease an open subject for practical investigation. An experiment in seed treatment for corn smut was carried out in both the field and silage corn, through the coöperation of the Agriculturist. Investigations were also made with respect to the amount of smut and parts affected.

No evidence of benefit was obtained from seed treatment of corn for smut. The infection appears to occur at a later stage in the life of the corn plant than in the oat plant or wheat plant. In counts of corn smut made in the Station fields, it was found that where a total of 4.42 per cent. of corn stalks were smutted upon some portion, 0.54 per cent. of the ears of the affected plants were a total loss from smut. One-half per cent. of grain loss upon the total crop of nearly 90,000,000 bushels in Ohio, indicates a large damage independent of that from fodder loss and possible stock sickness due to the corn smut.

OTHER PLANT DISEASES.

With the use of the Station forcing houses has come the question of diseases of green-house plants. A portion of the Botanist's time has necessarily been devoted to this phase of plant pathology. These studies are sufficiently advanced to call for early publication.

A paper upon "Galls of Raspberry, Peach and Pear" was presented before the Ohio State Horticultural Society at Canton, December, 1895. The galls of raspberries referred to, regarded as crown gall, disclose interesting and valuable points with respect to local occurrences of the disease. The obscure nature of these crown galls makes the subject a difficult one and added light most desirable. The only remedy to suggest is removal and destruction of affected plants. Further, diseased plants and plants from diseased plantations are a source of danger and of loss, which the grower should endeavor to avoid.

Some experiments have been tried for the prevention of scab and rot in corms of gladiolus. The material for trial was kindly contributed by the Cushman Gladiolus Co., of Euclid, O.

In the care of the Botanist's greenhouse and in other work, assistance has been rendered by Mr. W. E. Bontrager of the Horticultural Department.

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[3] Propagation and Prevention of Smut in Oats and Barley. Jour. Royal Agl. Soc., II s. s. II, 1888, p 4.

[4] Nachrichten aus dem Klub der Landwirthe zu Berlin, 1888, No. 222, p. 1601. Jour. Myc. Vol. VI, p. 164.

WEEDS.

The study of the occurrence and noxious character of weedy plants was continued during the year. A bulletin of inquiry, No. 59, "Noxious Weeds Along Thoroughfares and their Destruction" was issued in May, 1895. In this the Ohio Weed law was reprinted and special inquiries made concerning roadside weeds. It was sent to township clerks for road supervisors and others, in addition to the usual distribution. The responses obtained, in connection with other material, await publication. I desire to acknowledge my obligations to those, and they are many, who have assisted by specimens, lists of weeds and suggestions. There are constant requests for identification of plants. These calls receive prompt response and are taken to indicate widespread interest in weed and forage problems.

Three hundred and fifty determinations of specimens are recorded for 1895, and two hundred and twenty-five of these for the months of July, August and September. A portion of the species examined were parasitic fungi, but the larger part were weedy plants.

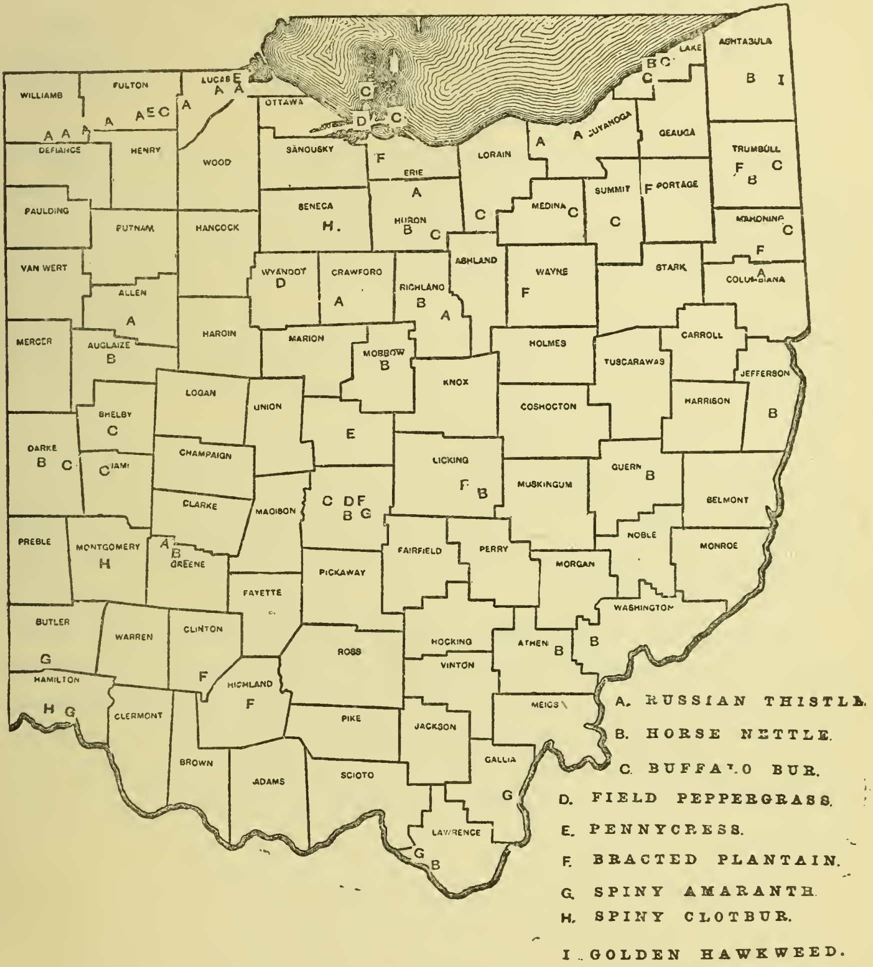
Analyzing these requests, in part, those sent the most frequently have been received the following number of times:

Prickly lettuce	28	times.	Bracted plantain	11	times.
Horse nettle	18	"	Buffalo bur	7	"
Rib grass	17	"	Spiny amaranth	7	"
Tumbleweed	16	"	Chicory	6	"
Canada thistle	14	"	Atriplex	5	"
Moth mullein	13	"	Wheat thief	3	"
Wild carrot	11	"	Field peppergrass	3	"
Sow thistle	7	"	Russian thistle	3	"

With a great variety of plants making up the remainder.

The distribution of the more noxious, or later arrivals among the weeds, possesses some interest. Prickly lettuce, *Lactuca scariola* L., appears to be over the whole State. Horse nettle, *Solanum Carolinense* L., known at points designated B, upon the map. [Map II] is a threatening perennial weed for southeastern Ohio. Rib grass or narrow plantain, *Plantago lanceolata* L., is nearly everywhere, but much the worst on light soils. Tumbleweed, *Amarantus albus* L., appears to be everywhere. Canada thistle *Carduus arvensis* L., is widely distributed. Moth mullein, *Verbascum Blattaria* L., is widely distributed, especially disseminated in grass seeds. Buffalo bur or prickly fruited solanum, *Solanum rostratum* Dunal., is a new comer, an annual and likely to become more scattered ; marked C upon the map. Field peppergrass, *Lepidium campestre* L (D) and penny cress, *Thlaspi arvense* L. (E), are two biennials of the mustard family, which require care to prevent their further spread. Bracted plantain, *Plantago aristata* Michx. (F), spiny amaranth, *Amarantus spinosus* L. (G), spiny clotbur, *Xanthium spinosum* L. (H) and golden hawkweed, *Hieracium aurantiacum* L. (I), are all new comers that will bear watching; the first comes from the west, chiefly in grass and clover seed, the second approaches from the south, and the last has just appeared in the northeast.

MAP II.



Showing Points of Occurrence of Russian Thistle, Horse Nettle, Buffalo Bur, Field Peppergrass, Pennycress, Bracted Plantain, Spiny Amaranth, Spiny Clotbur and Golden Hawkweed in Ohio, 1895.

The Russian thistle continues to spread in Ohio and is now known to have been found in ten counties and in the places approximately shown by A on the accompanying map.

The railway officials have shown commendable zeal in the prompt destruction of the Russian thistles appearing along their lines. As yet all known stations for the pest are upon railroad rights of way.

There is a demand for amendment of the Ohio Weed Law, especially with respect to the weeds named in it. Modifications upon this point might properly be made to include prickly lettuce, horse nettle, Russian thistle, and probably moth mullein among the outlaws.

The narrow and bracted plantains, broad plantains, sorrel, peppergrass, smartweed and some other seeds are very common in clover and grass seeds. The plantains and sorrel are certainly to be interdicted in this connection, if any weed seeds are.

In the furtherance of the efforts of the Botanical Department to disseminate the information sought from it, an extensive weed exhibit was prepared, including specimens of one hundred and seventy-five of commoner and more noxious weeds. The assistance of Mr. J. W T. Duvel, a special student in this department, and of Mr. W. E. Bontrager, enabled the Botanist to prepare the specimens. These were displayed at the Tri-State Fair and Exposition held at Toledo, August 24 27; at the Ohio State Fair, Columbus, September 2-5; and in part at the fairs of Medina, Wayne and Holmes counties.

The need of good illustrations to convey instruction and explanation concerning fungous diseases, parasitic fungi, disease symptoms and weeds is one that is constant. Provision for this is very desirable. Additional assistance would inure to greater economy in conducting the work entrusted to the department.

It is the design, as here interpreted, to assist all citizens of the State who may please to make use of the facilities offered, and inquiries concerning plant diseases caused by fungi, bacteria and other agencies, as well as those questions pertaining to weeds and other plants will receive prompt consideration. Practically all the lines of investigation mentioned in this report are designed to be continued as far as may be possible or useful.

REPORT OF THE CHEMIST.

AUGUSTINE D. SELBY, B. SC.

About four months was devoted to chemical work and some time has been absorbed in matters relating to the new laboratory now approaching completion. The temporary laboratory was closed May 1, the apparatus packed, and since that time all chemical investigation has been necessarily suspended.

A number of analyses of feeding stuffs and determinations of constituents of fertilizers were made, none of which have yet been published. In a part of this work. assistance was rendered by Mr. L. M. Bloomfield, and obligations to him are gladly acknowledged.

It is impracticable, and far from useful in many cases, to make indiscriminate examination of samples submitted with requests to analyze. The aim is rather to meet the applications coming within the Station's work. That this is rather difficult, while the chemical laboratory is kept open during some four months only, will be apparent to all.

Analyses of the fertilizing materials used, and if circumstances permit, of soils from the plots under experimental treatment, are under contemplation for 1896.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 59. May, 1895

NOXIOUS WEEDS ALONG THOROUGHFARES AND THEIR DESTRUCTION.

Especially for roadmasters, superintendents and road supervisors.

BY AUGUSTINE D. SELBY, BOTANIST.

In the treatment of the weed problem in Ohio, it does not seem possible to leave out of consideration the weeds of unoccupied lands, and especially those along highways and railroads. The number of weeds is very large and constantly increasing, and the habits of such weedy plants as grow within road fences will be almost or quite as variable as the general weeds of the given localities, yet there are particular reasons why attention should be given to roadside weeds now. At least one new weed pest, the Russian thistle, is attacking the State by this route almost exclusively; the cockle-bur has been in possession of roadsides for a long time, while prickly lettuce and other weeds of all sorts are neglected in these places and spread to adjacent lands. Travel on highways, the feeding of horses by the roadside, the transportation of products along railways, all conspire to spread weeds more effectively than they are scattered in the materials applied by the farmer himself.

OBJECT OF THIS INQUIRY.

It is the object of the present inquiry to collect, if possible, more complete data concerning roadside weeds than is now in the possession of the Experiment Station or than can soon be secured by representatives of the Station; and since a mere knowledge of them will do no good without remedies, it is hoped to secure a more thorough compliance with the statutory requirements as to weed destruction in our thoroughfares For this double purpose the request for information is made directly to those having the roadways in charge, to the superintendents and supervisors of public highways, and to the engineers of way, road masters and section foremen of railways, as well as to the interested citizens who use these lines of travel.

Those who receive this bulletin are therefore urgently requested to make use of the blank page on the back, fill it out, in pencil, with as large a list of roadside weeds as is consistent with circùmstances, noting, when possible, relative "badness," abundance, etc.; and to mail this list to the Experiment Station, Wooster, O.

But not this alone; the next step equally desired, even more to be desired, is the application of proper measures to reduce the injury resulting from roadside weeds. The urgent need of promptness in weed cutting and other means of destruction requires to be emphasized. Ohio roadsides are capable of very great improvement with respect to the weeds along them.

CONDITION OF ROADSIDES.

A wide variation may be found in this regard. Some counties will show clean roadsides, with scarcely any weeds, and an abundant growth of grass, while others have the reverse conditions frequent, if not prevalent. All turf forming grasses or clovers are usually welcomed, although the white melilot, sometimes called Bokhara or sweet clover, and possibly others, will be excepted. Only one who has ridden through such an array of weeds on either side of the road as may be found on some in Ohio, can form the extreme conception of bad roadsides.

The care of roadsides generally rests with the road supervisors and the township trustees; on improved roads there are superintendents and in villages and cities a street commissioner. Perhaps a manifest interest on the part of citizens in the various districts will aid in the proper discharge of their duties by the legal custodians.

RAILROAD RIGHTS OF WAY.

These are of course to be cared for by the railroad companies holding them. The statutes require burning them over at certain times as well as the cutting of weeds and bushes. On the whole the cutting is more carefully done along the railways than on highways, but improvement can and should be made in respect to time of cutting. This is often done too late, *after the seeds are matured.* It is easier, rather than more difficult, to do the cutting earlier, and this will be more effective to destroy weeds.

HOW CUTTING DESTROYS WEEDS.

Cutting weeds is recommended chiefly to prevent the ripening of seeds. For actual weed destruction the cutting must be done before the seeds are formed, usually before blossoming is far advanced. Cutting certain weeds below the crown will be of great advantage, but may not be expected, usually. The dates fixed in the Ohio Weed Law are intended to secure seed destruction of nearly all plants. *The importance of early and repeated cutting will scarcely be over estimated.*

Those whose duty it is to give directions in this matter are urged to make the requirements plain and the work effectual by supervision.

DISTRIBUTION OF THIS BULLETIN.

Copies of this bulletin will be distributed through township and city clerks, also through engineers of maintenance of way. The clerk receiving this bulletin, in each case, is urgently requested to file a copy for himself, one for the use of the township trustees or street commissioners, and to distribute a copy to each road supervisor or superintendent within his jurisdiction, calling attention to the information sought, and to the requirement for each in the way of weed destruction. Engineers of maintenance of way will receive copies in such number as they may require. These may be distributed for use among section foremen.

IDENTIFICATION OF WEEDS AND DETERMINATION OF NOXIOUS CHARACTER

When questions of identity or character of weeds arise, these may usually be determined by sending specimens, in flower if possible, with brief statement and sender's address on package, to OHIO EXPERIMENT STATION, *Wooster, O.* Such will receive attention, and all inquiries of this sort will be answered. Sender's address on the package is needed to identify the specimen sent, since a large number of packages is constantly coming in. When several specimens are sent at once, a paper slip, with number, may be attached to each. An illustrated bulletin upon the Russian thistle will be sent upon application.

OHIO WEED LAW.

The following is the Ohio statute pertaining to the destruction of weeds, as amended and passed April 25, 1893. (Ohio Laws, vol. 90, p. 301)

SECTION 4730. The superintendent of any improved or macadamized road, supervisor of county and township roads, or street commissioner of any city or village, shall, between the 15th and 30th days of June, and between the 1st and 15th days of August, and between the 15th and 30th days of September of each year, cut all brush, briers, Canada or common thistles, or other noxious weeds growing within the limits of any county or township road, improved or macadamized road, street or alley, within their jurisdiction. Such superintendent or supervisor shall be allowed $1.50 per day for all necessary labor, to be allowed by the trustees and paid by the treasurer of such township out of the road fund then in his hands. The superintendent or supervisor of any such roads may allow any landowner or tenant to cut and destroy any such brush, briers or weeds, growing on such highways, [along] the lands abutting on such highways owned or occupied by such landowner or tenant, and before such work is performed allow and fix a reasonable compensation therefor, which amount shall be credited on the road tax of that year assessed against said premises. The superintendent or manager of any toll road shall cut and destroy all brush, briers and noxious weeds growing within the limits of any such road, between the days of each month as above specified in this section, and in default thereof and for five days thereafter the trustees of any township through which any such road passes shall cause any such brush, briers and weeds to be cut and destroyed, and shall have right of action against any such toll road company, for the amount of such work, together with one hundred per cent. penalty and cost of action to be recovered before any justice of the peace of such county.

SECTION 4732 The trustees of any township of this state, upon information in writing that Canada or common thistles, oxeye daisy, wild parsnip, sweet clover, wild carrots, teasels, burdock or cockle-burs, are growing on any lands in their township and are about to spread or mature seed, between the first day of June and the fifteenth day of October of each year, said trustees shall cause notice in writing to be served upon the owner, lessee, agent or tenant having charge of any such lands, notifying such owner, lessee or agent or tenant that Canada or common thistles or other noxious weeds mentioned in this section are growing on such lands, and that such Canada thistles or other noxious weeds shall be cut and destroyed within five days after the service of such notice; and in default thereof, that said township trustees will enter upon such lands and cut and destroy such Canada or common thistles or other noxious weeds; and that the cost of cutting such Canada or common thistles or other noxious weeds, with the cost of such notice, will become a lien against said lands. Any constable or deputy marshal of any city or village, or deputy, is hereby authorized to make service and return of any such notice, and the fees for such services and return shall be the same as are allowed for service and return of summons in civil cases before magistrates. If any owner, lessee, agent or tenant having charge of any such lands shall fail to comply with such notice, the township trustees shall cause said Canada or common thistles or other noxious weeds to be cut and destroyed, and may employ any person to perform such labor, and allow such person fifteen cents per hour for the time occupied in performing such labor, and pay the sum for such labor out of any money in the treasury of said township not otherwise appropriated, and take receipt for the same. Said township trustees shall make return in writing to the board of commissioners of their county, with a statement of the charges for their services, the amount paid to the person for performing such labor, together with the fees of the officers who made the service of notice and return, with a proper description of the premises; and the same having been allowed, shall be entered upon the tax duplicate, and shall be a lien against said lands, from and after the date of such entry on the duplicate, and shall be collected as other taxes, and returned to the township with the general fund.

SECTION 4732*a*. That in all cities and incorporated villages, except cities of the first and second grade of the first class and first and second grade of the second class, the mayor shall, during the month of May of each year, cause notice to be published for two consecutive weeks in one or more newspapers published in the corporation, or by posting up written or printed notices in said city or village at three public places for ten days next previous to the first day of June of each year, warning the owners, lessees or agents of lots and lands within such city or village to cause all Canada or common thistles, or other noxious weeds mentioned in section forty-seven hundred and thirty-two, growing on any such lots or lands within said corporation, to be cut and destroyed so that they do not mature seed or spread to adjoining lands. The common council of such city or village shall, upon information in writing that Canada or common thistles or other noxious weeds mentioned in section forty-seven hundred and thirty-two are growing on any such lands, within their corporation, between the tenth day of June and the fifteenth day of October of each year, [shall] cause such Canada or common thistle or other noxious weeds to be cut and destroyed so that they do not mature seed or spread to other lands, and said council may employ any person to cut and destroy said noxious weeds and allow such person so employed fifteen cents per hour for the time employed in such labor. And said council shall pay said amount out of the money of the general fund in the treasury of said city or village not otherwise appropriated, and take a receipt therefor. And said council shall make return in writing to the board of commissioners of their county, with a statement of the amount paid for such labor, and one dollar additional as a penalty on each lot or parcel of land containing less than one acre, and with two dollars on each lot or parcel containing more than one acre. The same having been allowed, the auditor shall enter the amount so certified to him on the tax duplicate of the county against the lots or lands on which said Canada or common thistles or other noxious weeds were cut and destroyed, and the amounts shall be a lien against said lots or lands from and after such entry, and shall be collected as other taxes are collected, and returned to such city or village with the general fund; provided, that [if] any such owner of such lots or lands shall tender to the treasurer of such township in cases of townships, or to the treasurer of such city or village in the case of city or village, the amounts so chargeable against such lots or lands for such labor, together with the penalty as certified to by the clerk of said township, city or village showing the amount of such charges and penalty, the treasurer shall receive the amount so tendered, upon which said lots and lands shall be discharged from further liability.

SECTION 4732*b*. Township trustees shall be entitled to $1.50 per day for their services under this act; the mayor of any city or village, or trustees of any township, or superintendent or other officer of any toll road, or superintendent of any improved or macadamized road, or supervisor of any county or township road, or street commissioner of any city or village, who neglects or refuses to perform their duties as mentioned in sections 4730, 4732 and 4732*a*, shall be fined in the sum of fifty dollars in any court having competent jurisdiction of such cases; such fines shall go into the road fund of the township in cases against township or toll road officers; and into the street fund in cases against mayors or other municipal officers.

SECTION 3. This act shall take effect and be in force on and after the first day of May, 1893.

THE ROADSIDE WEEDS OF OHIO.*

Report from ……………………………………

Postoffice ……………………………………

County ……………………………………

Township ……………………………………

Official position ……………………………………

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* **Please detach this page, write upon it a list** of the most troublesome roadside weeds in your **vicinity,** and **mail it to the EXPERIMENT STATION, Wooster, O. Send specimens of weeds that you cannot name.**

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 60. August, 1895.

EXPERIMENTS IN FEEDING FOR BEEF.

BY C. E. THORNE AND J. FREMONT HICKMAN.

FIRST TEST.

In June, 1893, 32 three-year-old steers were purchased of farmers in the neighborhood of the Station. They were grades of mixed breeding, Shorthorn blood predominating, but there were several which showed an admixture of Holstein, Hereford and Jersey blood.

The steers were grazed on the Station farm during the summer and fall, and in January they were divided into nine lots, seven of four steers each and two of two steers each, the breeding and weight of the steers composing the different lots being shown in Table I, the attempt being made to make the seven larger lots as uniform as possible in the quality of the cattle composing them.

TABLE I.—BREEDING AND INITIAL WEIGHTS.

Lot.	No.	Breeding.	Initial weights.
			Pounds.
A	1	Grade Holstein	1,106
	2	" "	1,055
	3	" Shorthorn	982
	4	" "	932
		Average	1,019
B	5	Grade Holstein	1,072
	6	" "	1,069
	7	" Shorthorn	949
	8	" "	830
		Average	980

Table I—Concluded.

Lot.	No.	Breeding.	Initial weights.
			Pounds.
C	9	Grade Hereford	1,061
	10	“ Holstein	1,075
	11	“ Shorthorn	885
	12	“ Jersey	904
		Average	981
D	13	Grade Shorthorn	991
	14	“ “	1,082
	15	“ “	910
	16	“ “	881
		Average	966
E	17	Grade Shorthorn	1,004
	18	“ “	915
	*19	“ “	946
	20	“ Jersey	890
		Average	939
F	21	Grade Shorthorn	1,137
	22	“ “	952
	23	“ “	852
	24	“ “	898
		Average	960
G	25	Grade Shorthorn	1,099
	26	“ “	1,032
	27	“ “	960
	28	“ “	889
		Average	995
H	29	Grade Shorthorn	931
	30	“ “	832
		Average	881
I	31	Grade Shorthorn	776
	32	‘ “	830
		Average	803
		Average of H and I	842
		Average of all	960

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* Steer No. 19 met with an accident during the test, making it necessary to withdraw him from the experiment.

The "initial weight" as given in the above table is the average of three weighings, made on the 9th, 10th and 11th of January, and all live weights subsequently quoted, except the final weights in the stock yards, are likewise the average of three weighings.

To each of the three lots was apportioned a ration, composed as follows:

Lot A.—Wheat bran, corn meal, gluten meal, clover hay.
Lot B.—Wheat bran, corn meal, gluten meal, clover hay, corn silage.
Lot C.—Wheat bran, corn meal, oil meal, clover hay.
Lot D.—Wheat bran, corn meal, oil meal, clover hay, corn silage.
Lot E.—Wheat bran, wheat meal, gluten meal, clover hay, corn silage.
Lot F.—Wheat bran, wheat meal, oil meal, clover hay, corn silage.
Lot G.—Wheat bran, corn meal, clover hay, corn silage.
Lot H.—Wheat bran, corn meal, timothy hay, corn silage, fed in barn.
Lot I.—Wheat bran, corn meal, timothy hay, corn silage, fed in shed.

To lots A, B, C and D—16 steers in all—was given a basal ration consisting of equal weights of corn meal and wheat bran, with as much clover hay as they would eat; a ration of hay, containing a few pounds more than they would eat, being weighed out to them morning and evening, and the mangers cleaned out and the residue weighed next morning.

Lots E and F, eight steers, received wheat meal in equal weights with bran, instead of corn meal, with the same ration of clover hay.

In addition to this basal ration, all the cattle, except lots A and C, received corn silage, fed at the rate of 20 to 34 pounds per day, according to the appetite of the animal, some of the steers consuming the larger quantity regularly, while others always left more or less uneaten.

To three lots, A, B and E. gluten meal was fed, and old process linseed oil meal to lots C, D and F, beginning in each case with one pound per steer per day and increasing gradually until the gluten or oil meal constituted one-fourth of the entire grain ration.

Lots G, H and I received corn meal and bran alone, without either gluten or oil meal, but with hay and silage as fed to the other lots; the hay being timothy instead of clover for the two small lots, H and I, and the corn meal constituting 64 per cent. of the meal ration. As our barn held but 30 cattle, four of the smaller ones were divided into two small lots, H and I, lot H being fed in the barn and lot I in an open shed in the barnyard.

After the cattle had eaten their morning feed they were weighed, the weighing beginning at ten o'clock; they were then allowed to drink from a tub standing on scales in the barn, the amount of water drunk being determined, after which, in fair weather, when the thermometer was not below 20°, they were turned into an open barnyard until afternoon, when they were stabled again, earlier or later, according to the weather.

While in this barnyard the cattle had access to a stack of wheat straw and some straw was eaten. The quantity, however, was very small, as they were given all the grain and hay they could be induced to eat, and no attempt has been made to account for the straw in the following calculations.

The experiment would have been more satisfactory, from the scientific standpoint, had the consumption of straw been determined; but on the ordinary Ohio farm straw is valued only as bedding and as an absorbent of manure, and therefore the practical feeder takes no account of it as a part of his rations. For his purpose, therefore, the determination of the amount of straw consumed would have added nothing to the value of the experiment, since all the cattle were given all the meals, silage and hay they could be induced to eat.

We did not attempt to feed the wheat unground, because we believed that if fed in that condition much of it would pass through undigested. This might have been partly obviated by soaking, but soaking is hardly practicable in winter weather. We have for years followed the practice of feeding corn meal and wheat bran in equal weight, in the belief that both the physical condition and nutritive effect of both foods is improved by the mixture, and we believed that a similar result would follow the mixing of ground wheat with its weight in bran; we therefore decided to make bran the basis of all the meal rations, adding to it corn meal, wheat meal, etc., according to the object in view.

It is possible that we might have fed the wheat meal more successfully by sprinkling it on moist, cut hay and silage; but under this method of feeding we could not have determined the exact amount eaten, which was a necessary part of the experiment.

The meals, especially the gluten and oil meals, were fed in small quantity at first, the ration being gradually increased until the cattle showed signs of surfeit, when it would be reduced until they were eating freely again. During the latter half of the test the cattle receiving mixtures containing corn meal and bran as the basis consumed 15 to 16 pounds of meal per steer per day. In the case of the wheat meal mixtures greater difficulty in feeding was experienced, and the ration was not raised above 12 pounds per head per day.

COST OF INCREASE.

The experiment was begun January 11 and continued without change of plan for 120 days. The average results for this period are summarized in Table II, which gives for each steer the total feed consumed, both in ordinary and chemically dry condition, the initial weight and the total gain, and the average quantity of dry substance consumed and the cost of the same, to produce a pound of increase in live weight.

By dry substance is meant the absolutely dry material, after all the water has been driven off at a temperature of 212° Fahrenheit. This dry substance is made the basis of comparison because repeated experiments have demonstrated that the water contained in such watery foods as silage, for instance, has no more nutritive value than water drawn from a spring or well. Such water may add to the palatability of a food, but it does not add to its nutritive effect.

TABLE II.—FEED CONSUMED AND TOTAL GAIN, 1894.

Lot.	No	Weight at beginning of test.	Feed consumed.			Dry substance consumed.		Total gain.	Cost of feed.	
			Meals.	Hay.	Silage.	Total.	Per pound of gain.		Total.	Per pound of gain.
		Pounds.	*Pounds.*	*Pounds*	*Pounds.*	*Pounds*	*Pounds.*	*Pnds.*	$........	*Cents.*
A	1	1,106	1,802	1,297	....	2,775	9.84	282	20.00	7.09
	2	1,055	1,802	1,905	....	3,325	9.53	349	22.44	6.43
	3	982	1,802	1,061	....	2,561	10.58	242	19.06	7.87
	4	932	1,726	734	....	2,203	9.07	243	17.13	7.05
Average.		1,019	1,783	1,249	....	2,716	9.73	279	19.66	7.05
B.	5	1,072	1,721	495	4,010	2,950	10.07	293	21.15	7.22
	6	1,069	1,676	514	3,577	2,820	11.70	241	20.30	8.42
	7	949	1,698	470	2,902	2,638	9.13	289	19.47	6.74
	8	830	1,414	293	2,262	2,071	9.95	208	15.61	7.51
Average.		980	1,627	443	3,188	2,620	10.16	258	19.13	7.42
C.	9	1,061	1,793	1,346	....	2,811	14.06	200	21.71	10.86
	10	1,075	1,802	1,034	....	2,537	11.38	223	20.55	9.20
	11	885	1,766	1,002	....	2,476	13.91	178	20.09	11.29
	12	904	1,772	1,018	....	2,495	10.66	234	20.20	8.63
Average.		981	1,783	1,100	....	2,580	12.36	209	20.63	9.88
D.	13	991	1,148	335	3,681	2,215	12.24	181	16.38	9.05
	14	1,082	1,723	584	4,015	3,028	10.40	291	23.06	7.92
	15	910	1,654	216	2,855	2,353	8.62	273	19.49	7.14
	16	881	1,593	323	2,946	2,419	11.41	212	19.48	9.19
Average.		966	1,529	365	3,374	2,504	10.47	239	19.00	8.20
E.	17	1,004	1,375	507	2,868	2,382	10.40	229	17.99	7.85
	18	915	999	423	2,932	1,986	14.39	138	14.35	10.40
	19	....	....	....	....	....	....	....	....	....
	20	890	1,304	431	2,778	2,227	8.34	267	16.93	6.34
Average.		936	1,226	453	2,859	2,198	10.40	212	16.42	7.77

TABLE II.—Concluded.

Lot.	No.	Weight at beginning of test.	Feed consumed.			Dry substance consumed.		Total gain.	Cost of feed.	
			Meals.	Hay.	Silage.	Total.	Per pound of gain.		Total.	Per pound of gain.
		Pounds	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pnds.*	$........	*Cents.*
F.	21	1,137	1,378	344	4,018	2,510	11.05	227	19.06	8.40
	22	952	1,381	348	4,017	2,516	9.05	278	20.11	7.23
	23	852	1,328	644	2,857	2,456	9.00	273	19.32	7 08
	24	898	1,348	686	2,898	2,522	10 29	245	19.71	8.05
Average		960	1,358	505	3,447	2,501	9 78	255	19.80	7.74
G.	25	1,099	1,641	527	3 595	2,795	9.88	283	19.73	6.97
	26	1,032	1,626	296	3,204	2,479	12 21	203	18.20	8.96
	27	960	1.626	219	2,857	2,320	10.04	230	17.50	7.59
	28	889	1,619	267	2,932	2,377	11.37	209	17.68	8.46
Average.		995	1,628	327	3,397	2,493	10.78	231	18 27	7 90
H-1	29	931	1,642	313	1,727	2,142	10.65	201	16.54	8 23
	30	832	1,637	398	2,322	2,363	8.32	284	17.59	6 19
	31	776	1,638	194	2,904	2,321	8.35	278	17 51	6.30
	32	830	1,638	365	2,713	2,434	11.27	216	17.97	8.32
Average.		842	1,639	317	2,416	2,315	9 46	245	17.40	7.11
Av. of all		960	1,583	599	2,285	2,500	10.33	242	18.94	7.82

SECOND TEST.

After the sale of the 32 steers used in the test just described a second lot of 16 steers, of similar age and breeding, was purchased and grazed through the summer and fall. Like the previous lot, these steers were prepared by preliminary feeding in the fall, and on January 11 were put under systematic experiment, being divided for this purpose into five lots as shown in Table III:

TABLE III.—BREEDING AND INITIAL WEIGHTS.

Lot.	No.	Breeding.	Initial weight.
A	1	Grade Shorthorn	1,100
	2	" "	1,047
	3	Shorthorn Jersey	882
	4	Grade Holstein	986
		Average	1,003
B	5	Grade Shorthorn	1,060
	6	Shorthorn Jersey	1,046
	7	Grade Shorthorn	1,016
	8	Shorthorn Devon	914
		Average	1,009
C	9	Grade Shorthorn	1,022
	10	" "	1,014
	11	Shorthorn Jersey	871
	12	Grade Shorthorn	911
		Average	954
D	13	Grade Shorthorn	1,188
	14	" "	889
		Average	1,029
E	15	Native	968
	16	Grade Shorthorn	931
		Average	949
		Average of D. and E.	994
		Average of all	990

As in the previous test, the weights given in this experiment are the averages of three weighings, made on consecutive days.

The following rations were apportioned to these lots:

Lot A.—Wheat bran, wheat meal, gluten meal, hay and silage.
Lot B.—Wheat bran, wheat meal, gluten meal, hay and stover.
Lot C.—Wheat bran, corn meal, gluten meal, hay and silage.
Lot D.—Wheat bran, corn meal, hay and silage, fed in barn.
Lot E.—Wheat bran, corn meal, hay and silage, fed in shed.

The main objective points in this test were a repetition of the comparison between wheat meal and corn meal and a comparison between corn silage and the ordinary field-cured corn fodder of Ohio (called "stover" in the East.)

The cattle were handled as in the previous experiment, except that the meal ration was kept at a lower point, so that there were very few cases of surfeit during the test, and these occurred after the animals had been feeding for a week or more upon an unchanged ration.

Table IV gives for this test the data given in Table II for the previous test; these data covering the period of 110 days from January 11 to April 30, inclusive:

TABLE IV.—Feed Consumed and Total Gain, 1895.

Lot.	No.	Initial weight.	Feed consumed.			Dry substance consumed.		Total gain.	Cost of feed per pound of gain.
			Meals.	Hay.	Silage or stover.*	Total.	Per pound of gain.		
		Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds	Pounds.	Cents.
A	1	1,100	1,281	838	2,570	2,471	13.14	188	9.62
	2	1,047	1,281	699	2,570	2,340	12.00	195	9.00
	3	882	1,114	309	2,543	1,817	9.93	182	7.93
	4	986	1,165	540	2,548	2,187	11.95	183	9.22
Average.......		1,003	1,240	596	2,558	2,204	11.78	187	8.95
B	5	1,060	1,281	938	511*	2,524	12.25	206	8.16
	6	1,046	1,278	996	376*	2,449	16.55	148	11.14
	7	1,016	1,246	961	381*	2,364	14.41	164	9.72
	8	914	1,242	907	310*	2,297	12.35	186	8.60
Average.......		1,009	1,262	943	394*	2,401	13.64	176	8.93
C	9	1.022	1,279	723	2,384	2,323	10.61	219	7.50
	10	1,014	1,281	960	2,570	2,596	9.17	283	6.26
	11	871	1,087	445	2,018	1,815	12.26	148	9.02
	12	911	1,281	556	2,030	2,098	8.74	240	6.43
Average.......		954	1,232	671	2,250	2,208	9.90	222	7.01
D & E	13	1,188	1,291	1.097	2,570	2,723	12.16	224	8.00
	14	889	1.291	742	2,613	2,401	9.68	248	6.68
	15	968	1,265	884	2,492	2,483	10.10	238	6.63
	16	931	1.292	762	2,546	2,405	12.40	194	8.06
Average......		994	1,256	871	2,555	2,503	11.07	226	7.40
Av'ge of all...		990	1,247	770	2,483	2,335	11.93	203	8.10

* Stover.

The cost of food, as given in Tables II and IV, is based upon the market price of the feeding stuffs at the Station at the time the first experiment was made, with respect to the meals and hay, and upon an estimated relative value of $2 50 per ton for corn silage. Following are the prices:

Corn meal	$16 00	per ton.
Wheat meal	20.00	"
Gluten meal	18.00	"
Oil meal	26 00	"
Wheat bran	16.00	"
Clover hay	8 00	"
Corn silage	2.50	"

These values of corn meal and wheat meal correspond to a fraction over 39 cents per bushel for corn and to about 52½ cents per bushel for wheat, one-eighth being allowed for grinding.

Tables II and IV show a wide range of productiveness in the different steers, the variations due to individuality being so great that conclusions must be drawn with caution, even when lots of ten or twelve animals are compared. It must therefore be understood that the conclusions which follow are tentative only, and are subject to revision or reversal when our knowledge shall be increased by more extended investigation.

CORN MEAL *VS.* WHEAT MEAL.

The results of this comparison are summarized in Table V:

TABLE V.—COMPARISON OF CORN AND WHEAT MEALS.

Year.	Test food.	Lots compared.	No. of cattle compared.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of feed per pound of gain.
				Pounds.	*Pounds.*	*Cents.*
1894	Corn meal	B. D.	8	2.07	10.31	7.79
	Wheat meal	E. F.	7	1.98	10.02	7.75
1895	Corn meal	C.	4	2.02	9.90	7.01
	Wheat meal	A.	4	1 70	11 78	8 95

These results, as will be seen, are contradictory, the wheat meal showing the better result in 1894, and the corn meal in 1895.

OIL MEAL *vs.* GLUTEN MEAL.

Table VI shows the results of the comparison of oil meal and gluten meal, the oil meal being the ordinary, old process meal and the gluten meal being the product of the American Glucose Company, of Buffalo, N. Y. and Peoria, Ills., the two meals containing the following proportions of dry substance and protein as determined in our laboratory:

	Dry substance.	Protein.
Oil meal	90 25	37.81
Gluten meal, 1894	91.94	27.71
Gluten meal, 1895	91.81	22.81

TABLE VI.—COMPARISON OF OIL MEAL AND GLUTEN MEAL.

Year.	Test food.	Lots compared.	Number of cattle compared.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
				Pounds.	*Pounds.*	*Cents.*
1894	Oil meal	C. D. F.	12	1 96	10.78	8.52
	Gluten meal	A. B. E.	11	2 11	10.05	7.31
	Mixed meals with Gluten meal.	B.	4	2.15	10.31	7.42
	" " without " "	G. H. I.	8	1.98	10.10	7.49
1895	" " with " "	C.	4	2.02	9 90	7.01
	" " without " "	D. E.	4	2.05	11.07	7.40

The test of 1894 seemed to show clearly that, at the relative cost of the two feeding stuffs ($26.00 per ton for oil meal and $18 00 per ton for gluten meal), the gluten meal was much the cheaper food, and therefore the oil meal was not used again in 1895 In both tests, however, a ration of corn meal, bran and gluten meal was compared with a similar ration containing no gluten meal, the results being again in favor of the gluten meal.

CORN SILAGE AS PART OF A RATION.

In 1894, lots A and C received no silage, while lots B and D had the same meal and hay rations with silage in addition. The results are given in Table VII, together with the comparison in 1895 of silage with stover:

TABLE VII.—CORN SILAGE AS PART OF A RATION.

Year.	Test food.	Lots compared.	Number of cattle compared.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
				Pounds.	*Pounds.*	*Cents.*
1894	Ration with silage................	B. D.	8	2.07	10.31	7.79
	Ration without silage..............	A. C.	8	2.03	10.86	8.26
1895	Silage..............................	A.	4	1.70	11.78	8.95
	Stover.............................	B.	4	1.60	13.64	8.93

The silage in 1894 contained about eight per cent. of grain, as shown by frequent determinations, the quantity being considerably larger near the top of the silo. Up to February 20 the average was 17 per cent., after that date, 5 per cent. In 1894 the proportion of grain did not exceed one-half of one per cent., and ran quite uniformly near this quantity In 1894 the grain contained in the silage was a material addition to the ration, amounting to an average of a pound and a half per steer per day; but in 1895 the quantity was less than an ounce and a half per steer per day—probably not more than was found in the stover fed in comparison.

CORN SILAGE VS. CORN STOVER.

Our silage corn, planted late and on thin land, had failed to ear because of the drouth, so that it seemed practicable to make a direct comparison between corn fodder cured as silage and corn fodder field cured in the ordinary way. The fall was favorable for field curing, and the stover was put into the barn, after husking, in unusually good condition. It was cut before feeding, and was fed to the cattle at the rate of eight pounds per steer per day, while the silage was fed at the rate of 24 pounds per head per day; these quantities being adopted on the supposition that the dried fodder would contain about 75 per cent. dry substance and the silage about 25 per cent., thus making the two rations uniform in quantity of dry substance contained. It turned out, however, that the stover contained more dry substance and the silage less than was anticipated, the former averaging 93 per cent. and the latter only 20 per cent. of dry substance.

In computing the relative cost of the rations containing stover and silage the stover is valued at $3.00 per ton, which is about its market value here, while the silage is valued at $2.50, as in the previous test, though this is a high valuation for silage containing no grain. At these valuations, the cost of the increase made on the two rations was the same (see Table VII), but the silage-fed cattle made their gain on considerably less dry substance than those fed on stover, and, more than this, the silage-fed cattle consumed a much larger proportion of the silage than the stover-fed lot did of their ration. Up to April 30, 3,504 pounds of stover, or more than half the quantity fed, was left in the mangers. During the same period 29,794 pounds of silage were given to the other 12 steers, only 390 pounds of which were refused, or about one and one-third per cent.

But in previous experiments cows, when fed a large ration of silage (40 pounds per day) rejected a very considerable portion,[1] while it is probable that if these steers had not had plenty of good hay to fall back upon they would have consumed a larger proportion of the stover.

The experiment indicates, therefore, that our silage was more palatable to the cattle than the stover, though that was of better than average quality; while the cattle fed on stover consumed more dry substance in producing a pound of increase than those fed on silage.

Numerous experiments in the comparative feeding of corn silage and field-cured corn fodder (that is, stalks and ears) have been made by other Stations. Following is a brief summary of their results:

In 1883 the New Jersey Station found that the digestible portions of the silage and field-cured fodder were of equal value for milk production, but more digestible food was secured per acre, and that at less cost of harvesting and preserving, in the case of field-cured corn than in that of silage.[2]

At the Massachusetts Station the results of five years' experiments led to the conclusion that fodder corn, corn stover and corn silage, when fed pound for pound of dry matter, in place of English hay, compared well, as far as the quality and quantity of the milk and of the cream obtained were concerned.[3]

The Iowa Station made an experiment in 1889, from which the following conclusions were drawn:

> "In this instance it did not pay to put any corn fodder in the silos. The weather was so dry that the corn fodder was not injured in the field; it cost so much less than the silage when prepared for feeding, there was so much less waste by spoiling, the fodder was relished so much better by all kinds of stock, and produced so much better results in fattening and in milk, that there was no room for choice between it and the ensilage in our silos. When fed in moderate quantities with other coarse fodder, our ensilage was well relished, being cleaned up as well as other coarse fodders, or better."[4]

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[1] See Bulletin of this Station for June, 1889, p. 91.

[2] N. J. Exp. Sta., Ann. Rpt. 1883, pp. 127-144.

[3] Mass State Exp Sta, Sixth Ann. Rpt., p 19.

[4] Iowa Exp. Sta., Bulletin for August, 1889.

The Pennsylvania Station compared the digestibility of silage and field-cured corn fodder, and found the field-cured corn fodder more digestible by steers than the silage.[5]

The Maine Station found silage not superior to fodder in digestibility when fed to sheep.[6]

In an experiment made by the Michigan Station, "silage, though nearly a quarter had spoiled, lasted longer, gave more flesh, and cost less in preparation than the corn fodder."[7]

At the Missouri Station dry fodder for cows proved more effective than silage.[8]

At the Illinois Station, heifers fed on dry fodder made practically the same gain per pound of dry substance consumed as when fed on silage.[9]

At the Wisconsin Station several experiments have been made, which are summarized as follows in the Seventh Annual Report of the Station for 1890:

> "Corn silage with us has proved sometimes superior to dry fodder corn in nutritive value, sometimes inferior. Considering all trials conducted at this Station, the conclusion will be that properly cured corn fodder corn and corn silage of similar variety and maturity are of equal value for milk and butter production."[10]

At the Utah Station the results obtained from silage fed to steers and sheep were inferior to those obtained from dry fodder corn.[11]

At the Vermont Station, cows gave about nine per cent. more milk while fed on silage, but the milk was of better quality when the cows were fed on dry corn fodder; but in a subsequent test the silage showed better results.[12]

The logical conclusion of all this work is that the process of ensilage adds nothing to the nutritive value of a feeding stuff It does add to its palatability, however, when the method has been properly employed, and in consequence, a larger proportion of the fodder will be consumed. In regard to the cost of this method, we do not consider it any greater than that of the ordinary method of cutting and husking and stacking the stover, and not so great as cutting, husking and stacking and grinding the grain, and certainly all this must be done if the food materials are to be as thoroughly preserved and made as completely available as they are in well cured silage.

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[5] Penna. Exp. Sta, Ann. Rpt. for 1889, pp. 123-133.
[6] Maine Exp. Sta., Ann. Rpt. for 1889, pp. 49-57.
[7] Mich. Exp. Sta, Bulletin 47, April, 1889.
[8] Missouri Exp. Sta, Bulletin No. 8, 1889.
[9] Ill. Exp. Sta., Bulletin No. 9, May, 1890, pp. 302-314.
[10] Wis. Exp. Sta., Ann. Rpt 1891, pp. 80-97.
[11] Utah Exp. Sta., Bulletin No. 8, 1891, Bulletin 19, 1892, and Ann. Rpt. 1893, pp. 11-20.
[12] Vt. Exp. Sta, Ann Rpt 1891, pp. 75-86, and 1892, pp. 154-155.

CONCLUSIONS RESPECTING DIFFERENT RATIONS.

It will be observed that the effects of the different rations employed are in no case sufficiently marked to justify positive conclusions, except in the comparison of gluten meal and oil meals, which seems safely to warrant the statement that, for the fattening of cattle, these feeding stuffs are approximately of equal value, pound for pound, and that the one which can be bought for least money is the one to use.

The comparison of silage with stover would be equally decisive in favor of silage, but for the well known fact that cattle will eat corn stover much more freely than they did in this experiment when they have no other coarse food to take its place.

While the experiments need repetition in order to eliminate the factor of individuality, which is so liable to obscure results when small numbers of animals are dealt with, they nevertheless exhibit some very interesting points when taken collectively. Some of these are discussed in the following pages.

HEAVY *vs.* LIGHTER FEEDING.

It will be observed that the cattle fed in 1895 fattened more slowly and with a greater consumption of food per pound of increase than those fed the previous season. The treatment of the two lots differed in this respect: In 1894 we aimed to feed the cattle all the meals they would eat, beginning with a small ration, but increasing it as rapidly as they would take it until they began to reject it, then lowering the ration until it was eaten freely, when it would be increased again. Our object was to ascertain the highest limit at which grain might be safely fed, as a guide in future work. The result was that we had frequent cases of temporary surfeit, during which the live weight would remain stationary or retrograde for a week or more, but in most cases the interruptions to growth were but temporary, and were followed by a rapid increase in weight. In 1895 the meal rations were kept one or two pounds below the limit indicated in the previous test; there were very few cases of surfeit, and yet the gain was not so good. Apparently too large a proportion of the food was required to keep the vital machinery running.

EFFECT OF TEMPERATURE ON FATTENING CATTLE.

The weather during January and February, 1895, was much colder than during the same period of 1894, the average temperature at 7 A. M., for the three weeks beginning January 26, being near the zero point. During the first two weeks of this period the cattle showed no diminution in gain, but from February 9 to March 5 the average live weight of the herd was stationary, though the cattle were eating well.

We supposed, at that time, that this check in growth was due to the extreme cold; but in April a similar check occurred, this time beginning during a period of abnormally high temperature. Apparently, the effect of weather conditions upon fattening cattle is a matter for further study.

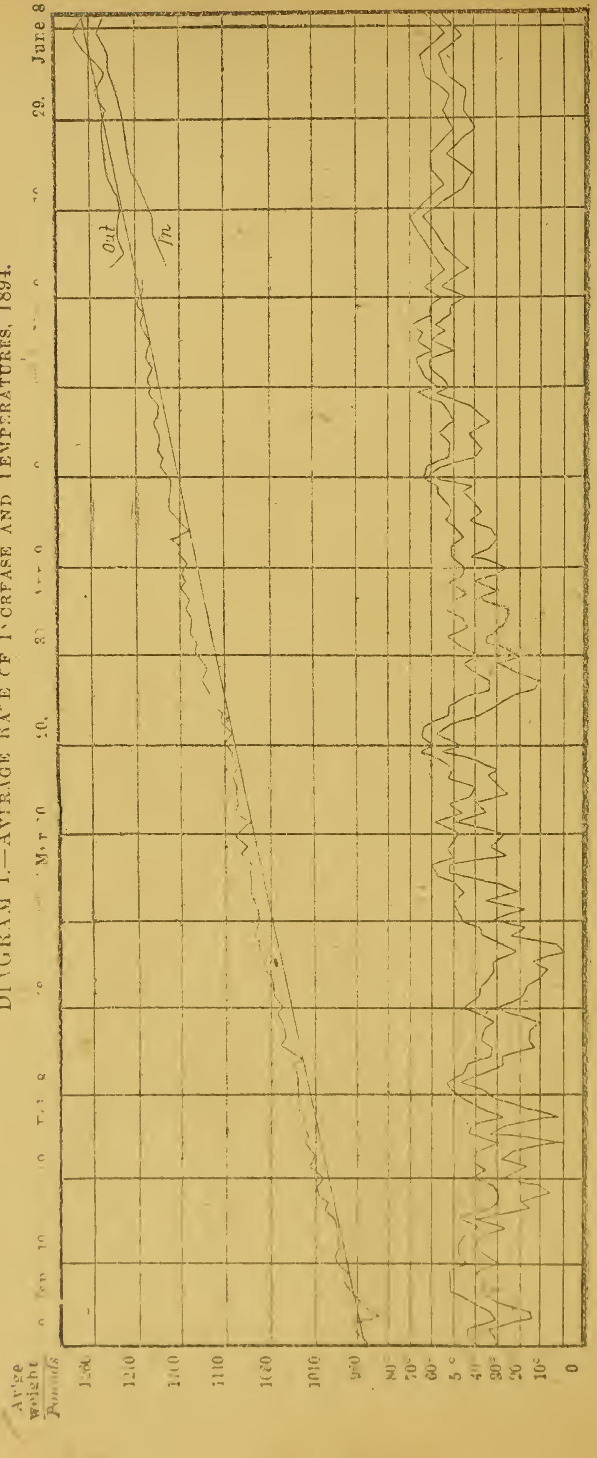
Diagrams I and II show the average rate of increase in weight of the two herds, and also the temperature at 7 A. M. each morning, the upper temperature line indicating the temperature inside the stable, the lower line the outside temperature.

FINISHING BEEVES ON GRASS.

On the 10th of May, 1894, half the steers were turned on grass, taking the alternate, odd numbers throughout the list, the cattle of even numbers being kept at the barn and treated as they had been through the winter. The cattle turned on grass were brought to the barn every evening, stabled through the night and fed night and morning. They continued to eat nearly as much meal and more than half as much hay and silage as the cattle which had no grass, but during the next thirty days they made an average gain of but 32 pounds per head, while the remainder of the cattle gained over 59 pounds each. The weather through May was cold and wet.

In 1895 this test was repeated on the same plan, and with similar results. In this case, the May weather was very dry, but variable in temperature, being abnormally warm during the first half of the month, followed by ten days of frosty nights. The cattle this year were turned out a week earlier, and were kept a week later before marketing, being shipped June 15, so that they had 45 days of grazing instead of 30. The result of this test is graphically shown in Diagrams I and II. In these diagrams the straight diagonal line indicates the average rate of increase of each lot from beginning to end of test, the zig-zag line running along this diagonal shows the daily variations in the average total weight of the herd, this line being divided into two at the point where the grazing experiment begins. It happened in both cases that the odd numbered steers, which were turned out, were heavier in the average than those kept in. In the second test, as in the first, the steers turned out gained less during the first 30 days than those kept in, but during the last 15 days of the second test it will be observed that the pastured steers made apparently a more rapid gain than those kept in, but in both tests the gain cost more in case of the pastured steers than in that of those kept in the barn.

DIAGRAM I.—AVERAGE RATE OF INCREASE AND TEMPERATURES, 1894.



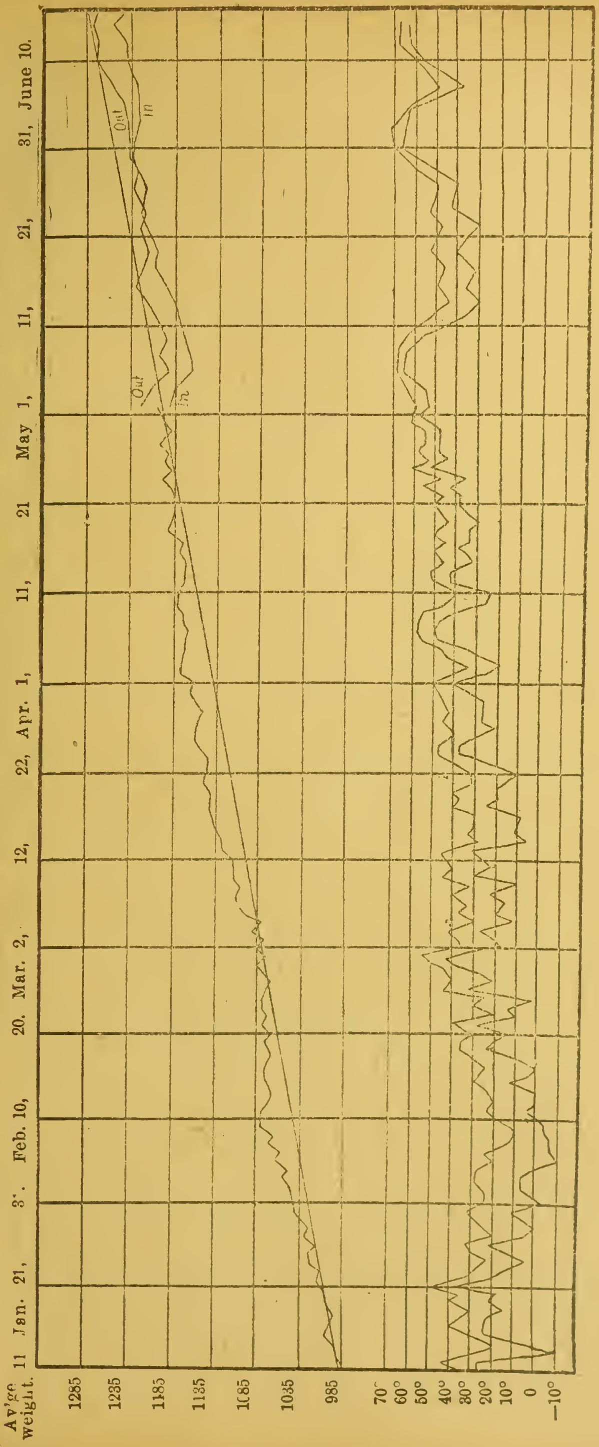


DIAGRAM II.—AVERAGE RATE OF INCREASE AND TEMPERATURES, 1895.

Both lots of steers were shipped to Pittsburg on Saturday, yarded over Sunday and sold on Monday, and in both cases the total weight on Monday at Pittsburg exceeded the final weight at home on Saturday, due to the fact that this final weight was taken before watering. In 1894 the pastured steers apparently lost least in shipment, while in 1895 the reverse was the case, but as the weight of water drank on the day of shipment was not taken we cannot give the relative shrinkage in shipment.

The data for this experiment are given in Table VIII:

TABLE VIII.—Finishing Beeves on Grass.

Year.	Treatment.	Number of cattle.	Days on pasture.	Dry substance consumed per steer per day.	Daily cost of food per steer.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
				Pounds.	*Cents.*	*Pounds.*	*Pounds.*	*Cents.*
1894	Kept in barn	16	....	20.16	15 33	2.00	10.00	7.66
	Pastured	15	30	15.39	12 93	1 42	10.84	9.10
1895	Kept in barn	8	....	20 99	16 09	1.76	11.95	9.15
	Pastured	8	45	15.21	12 55	1.37	10.68	9.14

This table shows that in 1894 the cost of food per pound of gain was greater in the case of the pastured steers than in that of those kept in the barn, and in 1895 it was practically the same, no allowance being made for the grass consumed in either case.

WARM BARN *VS.* OPEN SHED.

The barn in which these tests were conducted was a remodeled "Pennsylvania" barn, the overshoot having been inclosed with barn boards, the cracks well battened and several glazed windows added. The cattle stood in two rows of box stalls on a plank floor, with their heads toward a middle passage, and were tied with chains. They very soon became entirely reconciled to their quarters, and were handled without difficulty. In each experiment, two steers were fed in an open yard on the west side of the barn, the steers having a shed, closed to the north and east but open to the south and west, into which they could go at will and in which they were fed. Following is the average outcome of this comparison for the two tests:

Treatment.	Initial weight.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
Fed in barn	960	1.99	10.20	7.27
Fed in shed	876	1.93	10.53	7.33

The differences here indicated are not sufficient to justify the assertion that either method of caring for the cattle was better than the other, so far as the utilization of food by the cattle is concerned.

INCREASE AT DIFFERENT PERIODS OF FATTENING.

In Table IX the data concerning food consumption and increase are arranged in three periods, the first including the 60 days from January 11 to March 11, in both cases; the second including the 60 days from March 12 to May 10 in 1894, and the 50 days from March 12 to April 30 in 1895, and the third, the month ending June 9 in 1894, and 45 days ending June 14, 1895.

TABLE IX.—Increase at Different Periods of Fattening.

Year.	Period.	Season.	Dry substance consumed per steer per day.	Daily cost of food per steer.	Daily gain per steer.	Dry substance consumed per pound of gain.	Cost of food per pound of gain.
			Pounds.	*Cents.*	*Pounds.*	*Pounds.*	*Cents.*
1894	I	January and Febru'y.	20.81	15.11	2.21	9.40	6.83
	II	March and April	20.85	16.44	1.82	11.16	9.04
	III	May and June	20.16	15.33	2.00	10.00	7.66
1895	I	January and Febru'y.	20.98	13.85	2.19	9.57	6 32
	II	March and April	23.22	16 25	1.43	16.29	11.39
	III	May and June	20.99	16.09	1.76	11.95	9.15

In this table the data for May and June are for the steers kept in the barn. It will be observed that both lots of cattle show a better increase, both in rate and cost of gain, during May and June than during March and April, while both agree in showing a still better gain during the first period of feeding. The month of April, in both tests, was the period of slowest gain and greatest cost.

SOME POSSIBILITIES IN CATTLE FEEDING.

As was stated at the outset, the cattle fed in this experiment were a mixed lot. They included not only several grades of the dairy breeds, but several of those of purest shorthorn blood were not the best type of feeding cattle. But our object was to ascertain what might be done with the average Ohio steer, under the management of the average Ohio farmer. We believed that such an experiment would be useful in not only showing what might be expected of such a lot of steers as might be picked up in any county of Ohio, but that it would have a greater value if it showed the contrast between cattle of different feeding capacity than if it showed only the highest possible achievement.

Tables II and IV show that there was a wide difference in the utilization of their food by the different cattle. To show this point more clearly we have summarized the results in four groups below, arranging the groups according to the cost of feed required to produce a pound of increase:

TABLE X.—Summary of Tables II and IV.

Group.	Number of cattle.	Initial weight.	Total gain.	Dry substance consumed per pound of gain.	Cost of feed per pound of gain.
I.	11	950	277	9.32	6.52
II	12	979	246	9.85	7.47
III	13	983	213	11.62	8.41
IV................	11	990	180	13.20	9.84

It appears from the above summary that the cost of the increase was 50 per cent. greater in the case of the eleven worst steers than in that of the eleven best ones.

THE AVERAGE OUTCOME.

The total weight, at the beginning of the experiment, of the 31 steers which were fed throughout the first test, was 29,781 pounds (average 960), and the total weight of the same steers at the end of 120 days was 37,283 pounds, a gain of 7,502 pounds, or a small fraction over two pounds per steer per day. To produce this gain, the cattle consumed 49,071 pounds of mixed meals, 18,585 pounds of hay and 70,867 pounds of silage, the whole containing 77,500 pounds of dry substance. The daily consumption per steer was 13¼ pounds of meals, 5 pounds of hay and 19 pounds of silage, a total of 20 4-5 pounds of dry substance, no allowance being made for straw consumed nor for feed rejected.

The total cost of the feed consumed, at the prices given, was $587.04, or $7.82 per hundred pounds of gain.

The steers were finally sold in Pittsburg at $4.70 per hundred pounds, a price which netted $4 50 per hundred pounds at the station, making their value, at the end of the 120 days under review, $1,677.64. Deducting from this the cost of feed, $587.00, gives $1,090 64, which would be $3.66 per hundred pounds on their weight at the beginning of the experiment.

In other words, an advance in price of 84 cents per hundred pounds paid the cost of the food consumed during the test (excepting the straw), estimating it at its full market value, but making no allowance for the straw consumed, for the labor of caring for the cattle, nor for interest on the capital invested.

The initial weight of the 16 steers used in the second test was 15,846 pounds; their weight at the end of 110 days was 19,091 pounds, a gain of 3,245 pounds, or 1.8[illegible] pound per steer per day. These steers consumed in the four months 20 076 pounds of mixed meals, 29,407 pounds of silage, 1,578 pounds of stover and 12,881 pounds of hay, all containing 38,724 pounds of dry substance; the daily consumption per steer being 11.4 pounds of meals, 16.7 pounds of silage, 7.3 pounds of hay and .9 pound of stover, a total of 22 pounds of dry substance*

The total cost of food consumed was $262.92, or $8.10 per hundred pounds of gain. The steers were sold in June in Pittsburg at $5 00 per hundred pounds, netting $4.77 per hundred at the station, or a total value of $910 64 at the end of the 110 days. Deducting from this the cost of feed, as before, we have a net value of $647.72 at the beginning of the test, or $4.09 per hundred on the initial weight. In this case, therefore, an advance in price of 68 cents per hundred pounds paid the cost of food consumed during the test, with the exceptions already noted. As an offset against these items we have the manure produced:

VALUE OF MANURE.

Table XV (see appendix) gives the average per centages of moisture, ash, nitrogen, phosphoric acid and potash found in the common feeding stuffs, as compiled by W. H. Beal, of the Office of Experiment Stations, U. S. Department of Agriculture, and published in the Hand Book of

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*These steers were provided with straw, but they did not have access to the straw pile in the yard, as did those in the previous test.

Experiment Station Work. The analyses given are the averages of American analyses, unless otherwise noted:

On the basis of these analyses, the feeding stuffs used in the first experiment under review would have contained approximately the quantity of fertilizing constituents shown in Table XI:

TABLE XI.—FERTILIZING CONSTITUENTS IN FEEDING STUFFS.

Feeding stuff.	Quantity fed.	Fertilizing constituents.		
		Nitrogen.	Phos. acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Bran	19,106	510	552	307
Corn meal*	19,121	348	134	76
Wheat meal	3,644	86	32	22
Gluten meal	3,464	174	11	2
Oil meal	3,736	203	62	51
Clover hay	16,008	331	61	352
Timothy hay	2,577	32	14	23
Corn silage	70,867	198	78	262
Totals	....	1,882	944	1,095

*Estimated on the basis of corn kernels, the meal being unbolted.

The 7,500 pounds increase in live weight was chiefly water and fat. Experiments made on a large scale by Sir John B. Lawes indicate that such increase, in the case of cattle, would contain about 1.23 per cent. of nitrogen and 1.47 per cent. of ash. This ash would contain a small quantity of phosphoric acid and potash, but it is safe to assume that, after making full allowance for the fertilizing constituents carried away in this 7,500 pounds of increase, there would still be left not less than 1,8 0 pounds of nitrogen (equivalent to 2,200 pounds of "ammonia"), 900 pounds of phosphoric acid and 1,000 pounds of potash, to be returned to the soil, if all of the manure were carefully saved.

In the case under consideration the cattle were fed on a cemented floor, from which lines of sewer pipe, laid in cement, led to a cemented cistern, which collected all the liquid not caught by absorbents, and the solid excrement, with its straw, was carried into an open, saucer-shaped barnyard, where it was further mixed with straw from the stack already referred to. Undoubtedly part of the valuable constituents of the manure was lost by this treatment; but where such manure can be drawn directly to the field and immediately spread, the necessary loss is small. A covered barnyard would prevent loss from leaching, but would involve greater loss from heating unless great care was exercised.

In the Official Report of the Ohio State Board of Agriculture on Commercial Fertilizers for the year 1894, ammonia is valued at 17 cents per pound, soluble and reverted phosphoric acid at 6½ cents and potash at 6½ cents, these valuations being based on the average price of the ingredients in Ohio, as sold that year, in commercial fertilizers.

On the basis of these valuations the nitrogen, phosphoric acid and potash in the manure produced in the test of 1894 would be worth $497; $374 for the nitrogen, $58 for the phosphoric acid and $65 for the potash.

It is true that it would be practically impossible to save all the fertility thus produced and return it to the soil, especially the nitrogen. It is true, moreover, that it is possible to purchase nitrogen and phosphoric acid in forms in which they will give a quicker return than in stable manure; but it is also true that much of the nitrogen and phosphoric acid of ordinary commercial fertilizers are little if any more effective than those of manure, and in some cases they are undoubtedly less so—as when raw bone, or horn, hoof and leather shavings are used as the source of these constituents.

It is further true that these essential constituents of fertility may be purchased in forms at once more effective and less expensive than the ordinary, mixed fertilizers of commerce—that is to say, in nitrate of soda, basic slag or superphosphate, and muriate of potash; but it is also true that few farmers buy these materials.

It is further true that it costs more to apply fertility to the field in the form of stable manure than in that of the convenient "phosphate;" but it is also true that this extra cost is a very small item when the manure is simply hauled from the stable to the field on the ordinary farm.

It would seem, therefore, that after making full allowance for unavoidable losses of nitrogen, for slower availability and for greater expense in application, there would still remain value enough in the manure left by cattle fed under careful management to give a handsome profit on the feeding, provided the cost of the feed itself be recovered in the increased value of the cattle. The difference in price, however, which has been shown to be necessary to recover this cost is far below the difference which farmers expect to receive as a rule, and which a comparison of market quotations will show to be the rule, so that there is reasonable ground to expect a direct profit on the feed consumed, in addition to the indirect profit to be found in the manure.*

The cattle used in these tests were simply lots of ordinary, three-year-old steers, such as may be picked up in any county of Ohio, and certainly not above the average quality of the cattle of the State; in fact, an expert feeder, accustomed to the high-grade Shorthorns of the grazing regions of Ohio, Kentucky, Illinois and Iowa would have pronounced them unpromising lots of cattle for feeding.

The experiment (for both tests may be included as one) had for its prime object a general study of the conditions affecting beef production, a study designed to supplement the similar study of the production of milk, which has been carried on at this Station during previous years. It was made under such conditions as prevail on the ordinary, well managed farm, and its outcome, so far at least as rapidity of growth is concerned, has been excelled by many farmers. It was our purpose to arrive at an average basis in feeding, and we believe that our results, in regard to food required in fattening, may be accepted as safely within the limits of ordinary work.

In Table XII, republished from Bulletin 50 of this Station, we have compiled the results of such recent experiments in steer feeding by other Stations as contain the data necessary for comparison, from which it will be seen that our results were quite moderate.

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*The following table, compiled from statistics published by the Cincinnati Price Current, gives the average monthly range of prices in Chicago for good to choice steers, weighing 1,200 to 1,500 pounds, for the seven years, 1888 to 1894, inclusive :

PRICES OF CATTLE IN CHICAGO.

January	$3.15 @ $5.55
February	3.30 @ 5.35
March	3.60 @ 5.35
April	3.80 @ 5.30
May	3.90 @ 5.30
June	3.90 @ 5.60
July	3.55 @ 5.50
August	3.20 @ 5.65
September	3.15 @ 5 70
October	3 00 @ 5.85
November	3.00 @ 6.00

This table indicates that the average price of the lower grades of cattle is highest in May and June, and that of the higher grades in October and November. There is, of course, an advance in grade as cattle are fattened.

TABLE XII.—PRODUCTIVITY OF FOOD IN STEER FEEDING.

	Number of steers in test.	Age at end of test.	Gain in live weight.		Reference.
			Per day.	Per 100 lbs. dry substance consumed.	
		Years.	*Pounds.*	*Pounds.*	
Massachusetts........	7	1	1.36	9.24	Ann. Rpts. 1891 and 1892.
"	7	2	1.45	7.65	" " "
New York State.....	5	1½	1.27	11.29	" 1890.
Virginia...............	12	3	2.17	9.26	Bulletin 10.
Ontario...............	6	2	1.48	11.13	Exp. Farms Rpt. 1891.
Kansas	8	3	2.50	10.00	Bulletins 34 and 39.*
Maryland..	4	3	2.78	11.60	Bulletin 22.
Iowa	18	1	2.48	11.35	" 20.†
"	18	2	3.03	9.55	" 20.
Ohio	47	3	1.91	9.24	....
Average	....	....	....	9.77	....

* Dry matter estimated from Jenkins and Winton's tables, and comparison made with lots fed on balanced rations only.

† Dry matter estimated from Jenkins and Winton's tables. These steers and five of the Massachusetts steers were fed through two successive winters.

THE CHEMISTRY OF CATTLE FEEDING.

From 40 to 60 per cent. of the animal body consists of water, the quantity being smaller as the fatness of the animal increases.

Mineral substances (left as ash in burning) compose two to five per cent. of the entire body, varying from about 67 per cent. of the bones to a mere trace in the softer tissues and fluids. No part of the system is entirely destitute of minerals.

From 6 to 30 per cent. of the body consists of fat, the quantity varying with the condition of the animal. Pure fat is a chemical union of three elementary substances, carbon, oxygen and hydrogen. The same three substances, combined in different proportions, constitute the woody fibre and the starches, sugars and fats of plants. In the process of digestion and assimilation the fibre, starches and sugars (collectively called carbhydrates) serve first as fuel, for the support of the vital heat and for the production of motion or work; when more is consumed than is required for these purposes it is stored in the form of fat, this fat serving as a reservoir of fuel which may be drawn upon in case of deficiency of food. The fat of the food also serves the same purpose as the carbhydrates, for which it is estimated to be about two and one-fourth times as valuable, pound for pound. There seems to be a close parallelism between the nutritive values of fat and starchy matters and their fuel values, when burned for the production of heat.

A fourth important class of nutritive substances contains nitrogen and sulphur in addition to the three elements found in the carbhydrates and fat. These are the so-called protein compounds, also known as albuminoids. They contain about 16 per cent. of nitrogen and their office is that of growth and repair. In every cell of the vegetable or animal organism, which is charged with living functions, protein is found. It is consumed in relatively large quantities in the growth of young animals, and in the production of milk.

All feeding stuffs contain more or less water. In hays, grains, etc., the water content usually ranges between 10 and 15 per cent.; in silage it amounts to 70 or 80 per cent., and in roots, grass and green fodders it may reach 85 to 95 per cent.—a turnip or mangel may contain more water than would be found in the same weight of milk—but while the water of the food may add to its palatability, such water has no more nutritive value than water drawn from a spring or well. This point has been fully demonstrated.

Of the several mineral elements which appear to be essential to animal life the two most abundant are phosphoric acid and lime, these two constituting about four-fifths of the total ash; but if any one of the necessary mineral elements be absolutely withheld from the system life will soon cease.

In ordinary farm practice there is seldom any lack of mineral substances in food, especially in case of animals fed on the coarser feeding stuffs, but in exclusive grain feeding there is a possibility of reducing these constituents below the point needed for the most perfect growth. Thus Director Henry, of the Wisconsin Experiment Station, in summarizing the results of several experiments in pig feeding, says: "It appears plain to us that the excessive feeding of corn, with its deficiency in ash, tends to repress the natural development of the muscles, reduces the blood and some of the internal organs of the body and gives weak bones."*

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*Seventh Annual Report, Agricultural Experiment Station of the University of Wisconsin, page 32.

There is ground for the suspicion that the ash constituents are more liable to be deficient in human than in animal foods.

The protein supply is more liable to be deficient than that of minerals, especially where corn and timothy hay are the feeder's chief dependence, since these are both relatively deficient in this constituent. Our present knowledge of the laws governing nutrition justifies the statement that a certain amount of both minerals and protein is absolutely essential to assimilation, and that only so much of the carbhydrates and fat will be utilized as are required to balance the protein and minerals available. Protein, like the starches, etc., may be converted into heat and fat; but protein cannot be formed from starch or fat, since these are destitute of nitrogen.

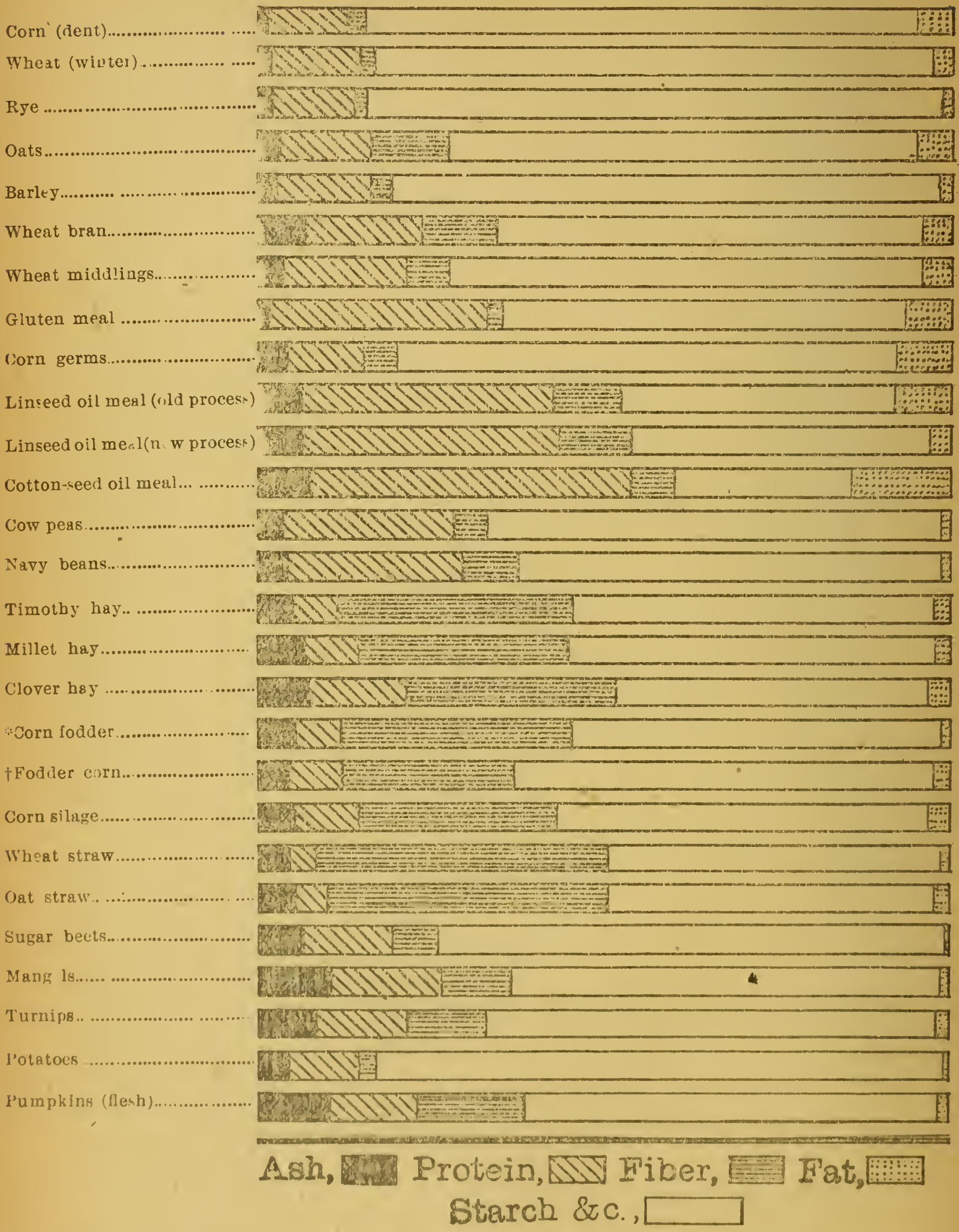
Diagram III shows the relative proportion of ash, protein, fiber, fat and starchy matters in 100 parts of the dry substances of a few of the more common feeding stuffs. This diagram illustrates the large proportion of protein in the various by-products—bran, middlings, gluten meal, etc.; the preponderance of fiber in the hays and straws, and the very interesting fact that, when divested of water, the most conspicuous difference between the grains and roots is the larger proportion of ash in the roots and of fat in the grains, the per centage of protein being nearly the same.

THE NUTRITIVE RATIO.

All substances used in animal nutrition are found, when subjected to chemical analysis, to be composed of two or more elementary substances, chemically combined. Water, for instance, is a combination of the two gasses, oxygen and hydrogen, united in the proportion of one volume of oxygen with two volumes of hydrogen. The starches, fats, etc., are composed of the elements of water, united with carbon, the three elements being always found united in certain fixed proportions. The protein compounds contain these three elements, united with nitrogen and sulphur, the proportions again being fixed and definite.

It seems highly probable that a similar law controls the assimilation of food in the animal body, and that the greatest effect will be produced from a given food when the constituents of that food bear to each other a certain ratio. What this ratio is we do not yet know; probably it varies within certain limits, according as the energy of the food is directed towards growth, the production of milk or wool, or the accumulation of fat, etc., somewhat as the same two gases which, when simply mixed together, give to us the air which is the breath of life, may form, when chemically combined in one proportion, the corrosive nitric acid, or in another proportion, the so-called "laughing gas." Chemical combination, it will be observed, is a very different thing from simple mixture.

DIAGRAM III.—Relative Composition of Dry Substance in Feeding Stuffs.



* Without grain—"stover." † Entire plant.

This probable parallelism has suggested the attempt to discover the laws governing assimilation, and we have heard much, in recent years, about the "nutritive ratio," by which is meant the proportion between the nitrogenous, or protein constituents of the food and the non-nitrogenous constituents—the carbhydrates and fats; the theory being that for some purposes—as growth and milk production—there should be a larger proportion of protein than is required for the maintenance of heat, for work or for fattening.

DIGESTIBILITY OF FOODS.

It is evident that such a law as that indicated can only apply to the digestible portions of the food; for in all foods there is a larger or smaller portion which is never dissolved by the digestive fluids, but passes through the body unchanged. Experiments made within recent years, in which both food and excreta were subjected to analysis, indicate that there is a wide difference in the digestibility of the different classes of foods and between the different constituents in the same class; thus a much larger proportion of the grains is digestible than of the straws and hays; the fats are more fully digestible than protein, etc.; and further than this, the combinations in which foods are used affect their digestibility.

The experiments upon which our present knowledge respecting the digestibility of foods is based have been made on comparatively few animals, and by methods which are confessedly crude, so that the most that can be said of this knowledge is that it is an advance beyond the absolute lack of exact information which formerly prevailed, and that calculations based upon the results of these experiments will be closer approximation to the actual truth than those which deal only with the total substance contained in the foods, as shown by chemical analysis. To illustrate: 100 pounds of the dry substance of wheat straw is found by experiment to contain on the average about 43 pounds of digestible matter, while the same quantity of the dry substance of the wheat grain contains about 84 pounds of digestible matter. In other words, there is about half as much digestible matter in wheat straw, as in an equal weight of wheat grain,—the percentage of water being nearly the same in both. Further than this, the digestion experiment shows that the two most valuable food constituents—protein and fat—are not only relatively deficient in the straw but are less digestible than the similar constituents of the grain; and thus, while of total digestible substance the grain contains only twice as much as the straw, yet of digestible protein it contains 12 times as much, and of digestible fat about four times as much.

In Table XIII, compiled by E. W. Allen, of the Office of Experiment Stations, U. S. Department of Agriculture, is given the average percentage of digestible constituents in 100 pounds of feeding stuffs, deduced as far as possible from American analyses and American digestion experiments:

TABLE XIII.—DIGESTIBLE FOOD INGREDIENTS IN 100 POUNDS OF FEEDING STUFFS.

Feeding stuff.	Dry matter.	Protein	Carbohydrates	Fat.	Fuel value.
Green fodder:	*Pounds.*	*Pounds*	*Pounds*	*Pounds.*	*Calories.*
Corn fodder[1] (average of all varieties)	20.7	1.10	12.08	0.37	26,076
Rye fodder	23.4	2.05	14.11	0.44	31,914
Oat fodder	37.8	2.69	22.66	1.04	51,624
Redtop, in bloom	34.7	2.06	21.24	0.58	45,785
Orchard grass, in bloom	27.0	1.91	15.91	0.58	35,593
Meadow fescue, in bloom	30.1	1.49	16.78	0.42	34,755
Timothy,[2] at different stages	38.4	2.28	23.71	0.77	51,591
Kentucky blue grass	34.9	3.01	19.83	0.83	45,985
Hungarian grass	28.9	1.92	15.63	0.36	34,162
Red clover, at different stages	29.2	3.07	14.82	0.69	36,187
Crimson clover	19.3	2.16	9.31	0.44	23,191
Alfalfa,[3] at different stages	28.2	3.89	11.20	0.41	29,798
Cowpea	16.4	1.68	8.08	0.25	19,209
Soja bean	28.5	2.79	11.82	0.63	29,833
Corn silage	20.9	0.86	11.79	0.65	25,714
Corn fodder,[1] field cured	57.8	2.48	33.38	1.15	71,554
Corn stover, field cured	59.5	1.98	33.16	0.57	67,766
Hay from—					
Orchard grass	90.1	4.78	41.99	1.40	92,900
Redtop	91.1	4.82	46.83	0.95	100,078
Timothy[2] (all analyses)	86.8	2.89	43.72	1.43	92,729
Kentucky blue grass	78.8	4.76	37.33	1.95	86,516
Hungarian grass	92.3	4.50	51.67	1.34	110,131
Meadow fescue	80.0	4.20	43.34	1.73	95,725
Mixed grasses	87.1	4.22	43.26	1.33	93,925
Rowen (mixed)	83.4	7.19	41.20	1.43	96,040
Mixed grasses and clover	87.1	6.16	42.71	1.46	97,059
Red clover	84.7	6.58	35.35	1.66	84,995
Alsike clover	90.3	8.15	41.70	1.36	98,460
White clover	90.3	11.46	41.82	1.48	105,346
Crimson clover	91.4	10.49	38.13	1.29	95,877
Alfalfa[3]	91.6	10.58	87.33	1.38	94,936

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[1] Corn fodder is entire plant, usually sown thick.

[2] Herd's grass of New England and New York

[3] Lucern.

TABLE XIII—Continued.

Feeding stuff.	Dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
Hay from—Concluded:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Cowpea	89.3	10.79	38.40	1.51	97,865
Soja bean	88.7	10.78	38.72	1.54	98,568
Wheat straw	90.4	0.80	37.94	0.46	73,998
Rye straw	92.9	0.74	42.71	0.35	82,294
Oat straw	90.8	1.58	41.63	0.74	83,498
Soja bean straw	89.9	2.30	39.98	1.03	82,987
Roots and tubers:					
Potatoes	21.1	1.27	15.59	....	31,360
Beets	13.0	1.21	8.84	0.05	18,904
Mangel-wurzels	9.1	1.03	5.65	0.11	12,888
Turnips	9.5	0.81	6.46	0.11	13,986
Ruta-bagas	11.4	0.88	7.74	0.11	16,497
Carrots	11.4	0.81	7.83	0.22	16,990
Grains and other seeds:					
Corn (average of dent and flint)	89.1	7.92	66.69	4.28	156,836
Barley	89.1	8.69	64.83	1.60	143,499
Oats	89.0	9.25	48.34	4.18	124,757
Rye	88.4	9.12	69.73	1.36	152,400
Wheat (all varieties)	89.5	10.23	69.21	1.68	154,848
Cotton seed (whole)	89.7	11.08	33.13	18.44	160,047
Mill products:					
Corn meal	85.0	7.01	65.20	3.25	148,028
Corn and cob meal	84.9	6.46	56.28	2.87	128,808
Oatmeal	92.1	11.53	52.06	5.93	143,302
Barley meal	88.1	7.36	62.88	1.96	138,818
Ground corn and oats, equal parts	88.1	7.59	61.20	3.72	143,276
Pea meal	89.5	16.77	51.78	0.65	130,246
Waste products:					
Gluten feed	92.2	20.40	43.75	8.59	155,569
Gluten meal	91.2	25.49	42.32	10.38	169,930
Hominy chops	88.9	7.45	55.24	6.81	145,342
Malt sprouts	89.8	18.72	43.50	1.16	120,624
Brewers' grains (wet)	24.3	4.00	9.37	1.38	30,692
Brewers' grains (dried)	91.1	14.73	36.60	4.82	115,814
Rye bran	88.4	11.45	50.28	1.96	123,089
Wheat bran, all analyses	88.5	12.01	41.23	2.87	111,188
Wheat middlings	84.0	12.79	53.15	3.40	136,996
Wheat shorts	88.2	12.22	49.98	3.83	131,855
Buckwheat middlings	86.8	17.34	26.58	4.54	100,850

TABLE XIII—Concluded.

Feeding stuff.	Dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
Waste products—Concluded:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds*	*Calories.*
Cotton-seed meal	91.8	37.01	16.52	12.58	152,653
Cotton-seed hulls	88.9	0.42	30.95	1.69	65 480
Linseed meal (old process)	90.8	28.76	32.81	7.06	144,313
Linseed meal (new process)	89.8	27.89	36.36	2.73	131,026
Peanut meal	89.3	42.94	22.82	6.86	151,263
Milk and its by-products:					
Whole milk	12.8	3.48	4.77	3.70	30 866
Skim milk—cream raised by setting	9.6	3.13	4.69	0.83	18,048
" cream raised by separator	9.4	2.94	5.24	0.29	16,439
Buttermilk	9.9	3.87	4.00	1.06	37 685
Whey	6.6	0.84	4.74	0.31	11,68[illegible]

The last column in the above table, headed "fuel value," indicates the heat and energy power of the food. It will be remembered that one of the primary functions of the food is to produce heat for the body and energy for work. The value of food for this purpose is measured in "heat units" or "calories,"[1] and is calculated from the nutrients digested. Thus the fuel value of one pound of digestible fat is estimated to be 4,220 calories, and of one pound of digestible protein or carbohydrates about 1,860 calories. The total fuel value of a feeding stuff is found by using these factors.

The meaning of the figures in the above table is that in 100 pounds of green corn fodder containing an average amount of dry matter (20.7 pounds) there are contained approximately 1.10 pounds of digestible protein (materials containing nitrogen), 12.08 pounds of digestible carbohydrates (starch, sugar, fiber, etc.), and 0.37 pound of digestible fat; and that these materials when burned in the body will yield 26,076 calories of heat, furnishing energy for work and maintaining the temperature of the body.

THE CALCULATION OF RATIONS.

With such a table before us as the one just given, it is possible to so adjust a ration that it may contain any desirable proportion of the different nutritive constituents.

To illustrate: The average daily ration consumed by the four steers of lot A in our first experiment consisted of 14.86 pounds of mixed meals and 10.41 pounds of clover hay. About 22 per cent. of the meal ration was gluten meal, the remainder being bran and corn meal in equal parts. Such a ration would contain the following quantities of digestible nutrients as calculated from Table XII:

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[1] A calorie of heat is the amount required to raise the temperature of a pound of water about 4° Fahrenheit.

DIGESTIBLE NUTRIENTS IN RATION.

Food.	Protein.	Carbhydrates.	Fat.
	Pounds.	*Pounds.*	*Pounds.*
3.28 lbs. gluten meal	0.83	1.39	0.34
5.79 lbs. wheat bran	0.70	2.39	0.17
5 79 lbs. corn meal	0.46	3.86	0.24
10.41 lbs. clover hay	0.68	3.68	0.17
Totals	2.67	11.32	0.92

Multiplying the total fat by two and one-fourth and adding the product to the carbhydrates we have a total sum of 13.37, which is approximately five times the amount of the protein, hence we say that the nutritive ratio is one to five.

After this manner the rations fed to the different lots of cattle in the two experiments have been calculated, the results being given in Table XIV :

TABLE XIV.—DIGESTIBLE NUTRIENTS CONSUMED.

Year.	Lot.	Digestible nutrients consumed.				Calories consumed per pound of gain.	Nutritive ratio.
		Per head per day.			Total per pound of gain.		
		Protein.	Carbhydrates.	Fat.			
1894	A	2.67	11.32	0.92	6.41	12,875	1 : 5
	B	2.29	12 39	0.67	7.25	14,520	1 : 6.3
	C	2 70	10.57	0.80	8.09	16,121	1 : 4.6
	D	2 24	10 66	0.85	6.89	13,825	1 : 5.6
	E	1.93	9.48	0.70	6.87	13,586	1 : 5.7
	F	2 21	10.43	0 63	6.23	12,293	1 : 5.3
	G	1.58	12 09	0.72	7.46	14,775	1 : 8.7
	H I	1.53	11.39	0.68	6 67	13,195	1 : 8.4
1895	A	2.19	10 44	0.77	7.88	15,726	1 : 5.6
	B	2.28	10.42	0.73	8.40	16,702	1 : 5.3
	C	2.14	10.12	0.85	6.62	13,299	1 : 5.7
	D E	1.79	12.57	0.71	7.33	14,453	1 : 7.9

It would seem, from these results, that there are other factors governing the productivity of a ration which are of more importance in the fattening of cattle than the mere ratio of its nutritive constituents, and this is in accord with our general knowledge of the functions of the different materials.

When coal is burned under the boiler of an engine a chemical combination takes place between the carbon of the fuel and the oxygen of the atmosphere, attended with evolution of heat, which heat is converted into work through the expansive force of steam. When food is taken into the stomach the digestive processes set up there a chemical action in which the carbon of the food is recombined, this process likewise being attended with heat as manifested in the constant maintenance of the high temperature of the body. If more food is taken than is required for heat maintenance the surplus may be stored in the form of fat, or it may be expended in work, while if the food be less in quantity than that required for heat maintenance, the heat will still be kept up by drawing upon the stored up fat of the body.

For the production of heat under artificial methods the protein constituents of the food are found to be equal, but not superior to the carbhydrates, the nitrogen of the protein compounds being simply inert so far as heat production is concerned, and this appears to be equally true in the production of heat, or its reciprocals, fat storage and work, in the animal mechanism; but when the resultant of the food energy is growth, then something more than the elements of heat are required; for this process involves the production of living tissue, and no such tissue can be formed in the absence of nitrogen and certain minerals. Even the storage of fat in mature animals is attended with some destruction of old tissues and their renewal, so that some protein is required in a ration for any purpose; but the quantity necessary for this purpose will evidently be less than that required for the growth of young animals.

FEEDING STANDARDS.

The following tables give the feeding standards compiled by Emil Wolff, of Germany, and which are generally accepted as approximately the proportions in which the different food constituents may be used with best effect for the various purposes named, the "nutritive ratio" being calculated by multiplying the digestible fat by two and one-half, adding this to the carbhydrates and dividing by the protein. The factor two and one-half was used by Wolff but later investigators prefer two and one-fourth, as probably more nearly correct.

TABLE XV.—Wolff's Feeding Standards.

A.—*Per Day and Per* 1,000 *Pounds Live Weight.*

	Total organic matter.	Digestible food materials.			Nutritive ratio.	Fuel value.
		Protein.	Carbhydrates.	Fat.		
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*		*Calories.*
Oxen at rest in stall	17.5	0.7	8.0	0.15	1 : 12.0	16,815
Wool sheep, coarser breeds	20.0	1.2	10.3	0.20	1 : 9.0	22,235
Wool sheep, finer breeds	22.5	1.5	11.4	0.25	1 : 8.0	25,050
Oxen moderately worked	24.0	1.6	11.3	0.30	1 : 7.5	24,260
Oxen heavily worked	26.0	2.4	13.2	0.50	1 : 6.0	31,126
Horses moderately worked	22.5	1.8	11.2	0.60	1 : 7.0	26,712
Horses heavily worked	25.5	2.8	13.4	0.80	1 : 5.5	33,508
Milch cows	24.0	2.5	12.5	0.40	1 : 5.4	29,590
Fattening steers:						
First period	27.0	2.5	15.0	0.50	1 : 6.5	34.660
Second period	26.0	8.0	14.8	0.70	1 : 5.5	36,062
Third period	25.0	2.7	14.8	0.60	1 : 6.0	85,082
Fattening sheep:						
First period	26.0	3.0	15.2	0.50	1 : 5.5	85,962
Second period	25.0	8.5	14.4	0.60	1 : 4.5	35,826
Fattening swine:						
First period	36.0	5.0	27.5		1 : 5.5	60,450
Second period	31.0	4.0	24.0		1 : 6.0	52,080
Third period	23.5	2.7	17.5		1 : 6.5	87,570

B.—*Per Day and Per Head.*

	Average live weight per head.	Total organic matter.	Digestible food materials.			Nutritive ratio.	Fuel value.
			Protein.	Carbohydrates.	Fat.		
Growing cattle:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*		*Calories.*
Age—							
2 to 3 months	150	8.3	0.6	2.1	0.30	1 : 4.7	5,116
3 to 6 months	300	7.0	1.0	4.1	0.30	1 : 5.0	10,750
6 to 12 months	500	12.0	1.3	6.8	0.30	1 : 6.0	16,332
12 to 18 months	700	16.8	1.4	9.1	0.28	1 : 7.0	20,712
18 to 24 months	850	20.4	1.4	10.3	0.26	1 : 8.0	22,859
Growing sheep:							
Age—							
5 to 6 months	56	1.6	0.18	0.87	0.045	1 : 5.5	2,143
6 to 8 months	67	1.7	0.17	0.85	0.040	1 : 5.5	2,066
8 to 11 months	75	1.7	0.16	0.85	0.037	1 : 6.0	2,035
11 to 15 months	82	1.8	0.14	0.89	0.032	1 : 7.0	2,051
15 to 20 months	85	1.9	0.12	0.88	0.025	1 : 8.0	1,966
Growing fat swine:							
Age—							
2 to 3 months	50	2.1	0.33	1.50		1 : 4.0	3,496
3 to 5 months	100	3.4	0.50	2.50		1 : 5.0	5,580
5 to 6 months	125	3.9	0.54	2.96		1 : 5.5	6,510
6 to 8 months	170	4.6	0.58	3.47		1 : 6.0	7,533
8 to 12 months	250	5.2	0.62	4.05		1 : 6.5	8,686

The digestible nutrients consumed per day by the average steer in our feeding experiment were as follows:

Total dry substance	21.2	pounds.
Protein	2.13	"
Carbhydrates	11.00	"
Fat	0.75	"
Nutritive ratio	1 : 6	
Calories	27,568	

As the average weight of our steers was considerably over 1,000 pounds, it will be seen that their recorded daily consumption of food was much less than that estimated in the German calculations, and it is not at all probable that enough straw was eaten to make up the difference.

COMPARATIVE VALUE OF FEEDING STUFFS.

1.—NUTRITIVE VALUE.

Of all feeding stuffs used in Ohio it is probable that the price of none is governed so exclusively by its intrinsic value as a food for animals as is that of corn. The soil and climate of this State give to this plant its most perfect development, and long experience has demonstrated its value as a food for all kinds of animals. It is used to a comparatively limited extent as a source of human food, or in the production of liquors, and its value is fixed, not by the price in Liverpool, as in the case of wheat, but by the local supply and demand. Its annual product in Ohio exceeds in weight of grain that of all other grain crops, and its cured stalks and leaves nearly equal in weight the annual hay crop of the State.

The average price of corn in Chicago, since 1880, has averaged about 45 cents per bushel. It is worth about as much at the average shipping points in Ohio as in Chicago, and it can be taken from the farm to this average shipping point for less than five cents per bushel. 40.8 bushels of corn will make a ton of unbolted meal, deducting one-eighth for grinding. It seems, therefore, that $16.00 per ton may be assumed as a fair average price for corn meal on the Ohio farm, the expense of hauling to and from the mill not greatly exceeding that of hauling to the shipping point, and being partly compensated by lower tolls in some sections and by home grinding on many farms.

Of the feeding stuffs which are relatively rich in protein, wheat bran is undoubtedly the one most used on Ohio farms. Made at many hundreds of mills, scattered over the State, it is within easy reach of every farmer. Its average cost on the farm is probably not far from $15 per ton.*

On the basis of these valuations we make the following comparison of the relative cost of digestible protein on the one hand and of digestible carbhydrates and fat on the other in these standard feeding stuffs, the fat being reduced to its starch equivalent by multiplying by two and one-quarter :

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*The average prices of No. 2 yellow corn and wheat bran in the Pittsburg market for the year 1894 were 49 cents per bushel, and $14.88 per ton. Deducting freight, the value of corn would be about 44 cents at the average shipping point. The wholesale price of bran in Pittsburg is probably not far from the retail cost to the farmer, by the time it reaches his farm.

Feed.	Digestible constituents.		Cost per cental.
	Protein	Carbhydrates.	
	Per cent.	*Per cent.*	*Cents.*
Corn	7.92	76.32	80
Wheat bran	12.01	47.69	75

It appears from this comparison that 100 pounds of bran contain about 62½ per cent. of the carbhydrates and equivalent fat found in corn. We may therefore reduce both feeds to the same carbhydrate basis by multiplying the corn constituents and price by .625, as follows:

100 pounds bran, costing 75 cents, contains 12.01 pounds protein and 47.69 pounds carbhydrates.

62½ pounds corn, costing 50 cents, contains 4.95 pounds protein and 47.69 pounds carbhydrates.

Difference in protein, 7.06 pounds, costing 25 cents.

From which we find that, on the basis of this comparison, the protein in these feeds costs 3.55 cents per pound. By the same method we find the cost of the carbhydrates to be about 0.68 cent per pound.

2.—MANURIAL VALUE.

In addition to these nutritive values, our animal feeding stuffs have an incidental, but by no means unimportant value as sources of fertility; and indeed some of them, as cotton-seed and linseed oil meals and wheat bran, may sometimes be used directly for this purpose, in competition with the ordinary fertilizers of commerce: For instance, the Connecticut Experiment Station, which was the first fertilizer control station in America and has given most careful study to this question, says, in its eighth annual report:

> "Attention is again called to the merits of Cotton Seed Meal as a fertilizer. It is the cheapest supply of available organic nitrogen now in the market. Experience demonstrates that it is very prompt to act and quite odorless. Its use as a fertilizer seems to be mostly confined to tobacco, but it is equally valuable for other crops, and at present rates deserves to be used extensively, to replace the higher priced nitrogen of dried blood, tankage and ground bone."

Analyses made by the Connecticut Station show that nitrogen may be purchased in cotton-seed meal at about 15 cents per pound (equivalent to 12¼ cents for ammonia), making due allowance for the phosphoric acid and potash contained in the meal, these being valued at five cents and four and one-half cents per pound respectivley.

On the basis of these valuations, we have compiled from Table XIII and Table XVI which follows, a table showing the fertilizing constituents contained in one ton of some of the more common feeding stuffs; the manurial value of the e fertilizing constituents; the feeding value, calculated as has been shown, and the average market value in 1894, as nearly as can be estimated from data at hand:

TABLE XV.—Comparative Values of Feeding Stuffs Per Ton of 2,000 Pounds.

Feeding stuff.	Fertilizing constituents per ton.			Manurial value per ton.	Feeding value per ton.	Market value per ton.
	Nitrogen.	Phosphoric acid.	Potash.			
Green fodder:	*Pounds.*	*Pounds.*	*Pounds.*			
Corn fodder [1](average all varieties)	8.2	3.0	6 6	$1.66	$2.54	....
Timothy grass, at different stages	8.6	3.2	15.2	2.34	5.08	....
Hungarian grass	9.6	5.2	15.2	2.09	3 59	....
Red clover	10.6	2.6	9.2	2.11	4.40	....
Cowpeas	5.4	2.0	6.2	1.17	2.36	....
Corn silage	5.6	2.2	7.4	1.27	2.42	....
Corn silage, more mature	....	....	....	....	3.25	....
Hay, and dry, coarse fodder:						
Corn fodder,[1] field cured	35.2	10.8	17.8	$6.57	$6.82	....
Corn stover[2]	20.8	5.8	28.0	4.60	6.17	....
Hay from timothy (all analyses)	25.2	10.6	18.0	5.09	8.43	[3]$8.46
Hay from Hungarian grass	24.0	7.0	26.0	5.05	10.64	....
Hay from red clover	41.4	7.6	44 0	8.46	10.00	....
Hay from cowpeas	....	....	....	....	13.25	....
Wheat straw	11.8	2.4	10.2	2.32	5.47	....
Rye straw	9.2	5.6	15.8	2.33	6.44	....
Oat straw	12.4	4 0	24.8	3.11	7.00	....
Roots and tubers:						
Potatoes	4.2	1.4	5.8	$1.00	$3.02	....
Beets (red)	4.8	1.8	8.8	1.18	2.08	....
Mangel-wurzels	3.8	1.8	7.6	.98	1.41	....
Turnips	3.6	2.0	7.8	.97	1.49	....
Grains:						
Corn (ave'ge of dent & flint) ground	36.4	14.0	8.0	$6.50	$16.00	$16.00
Oats, ground	41.2	16.4	12.4	7.52	14.42	[4]21.42

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[1] Entire plant. [2] Fodder, without grain. [3] Average farm price of hay in Ohio, Dceember 1, 1894, as reported by U. S. Department of Agriculture. [4] Average price in Chicago, 30c per bushel

TABLE XV—Concluded.

Feeding stuff.	Fertilizing constituents per ton.			Manurial value per ton.	Feeding value per ton.	Market value per ton.
	Nitrogen	Phosphoric acid.	Potash.			
Grains—Concluded:	*Pounds.*	*Pounds.*	*Pounds.*			
Wheat (all varieties) ground	47.2	16.0	11.4	$8.36	$17.19	$[5]20.00
Rye, ground	35.2	16.4	10.8	6.55	16.37	18.45
By-products, etc.:						
Corn and cob meal	28.2	11.4	9.4	$5.20	$13.12	$13.04
Gluten meal	100.6	6.6	0.1	15.43	27.03	18.00
Wheat bran (all analyses)	53.4	57.8	32.2	12.27	15.12	15.00
Wheat middlings	52.6	19.0	12.6	9.37	17.36	16.70
Wheat flour	....	....	....	....	16.77	[6]22.34
Hominy feed	32.6	19.6	9.8	6.28	14.88	....
Cotton-seed meal	147.0	51.8	36.0	26.26	32.37	26.20
Linseed oil meal, old process	108.6	33.2	27.4	19.11	27.04	[7]26.79
Linseed oil meal, new process	115.6	36.6	27.8	20.35	25.58	18.00

[5] Equivalent to 52½c. per bushel. [6] Average price of low grade flour at Pittsburg for 1894.
[7] Average price at mills for domestic sales for year ending July 31, 1894

The manurial value, as given in Table XV, is based upon prices much lower than those at which commercial fertilizers are ordinarily sold at retail, though it is possible to purchase nitrogen, phosphoric acid and potash in their cheapest forms at these rates. A similar valuation would rate barnyard manure at about two dollars per ton, whereas its value, as compared with the average prices of mixed fertilizers in Ohio, is nearly three dollars per ton.

It should be understood that neither the manurial nor feeding values are given as absolute values. What they mean is that, at the average market prices of standard fertilizers and feeding materials, the various feeding stuffs are worth the prices given, as compared with each other, no allowance being made for relative convenience in handling nor for adaptability to special purposes.

It will be observed that in many cases there is a very close agreement between the calculated feeding value and the market value. Corn silage has no market value, not being a material suitable for handling, but its calculated value corresponds very closely to the estimated value, deduced from the results of our first feeding experiment, the silage used in that test being a little better, perhaps, than the first sample quoted in the table, but not equal to the second.

The market value of clover hay is considerably lower than that of timothy; but its actual feeding value is undoubtedly higher. This is because of the prejudice against clover hay as a feed for horses. Those who have fed perfectly cured clover hay know that this prejudice is due to the great difficulty in curing clover hay in our climate, and not to any defect in the clover itself. When properly cured it is as valuable a feed for horses as for any other animals.

The values given to the straws in this comparison may seem high; but it must be remembered that all these valuations are based upon the effect of rations made up of different foods, bearing to each other the proportions best adapted to complete digestion. If straw were fed alone it would show no such value as that given, but when fed in small quantities and in connection with other foods giving the proper balance to the ration it is probably worth the price indicated, in comparison with other foods, and this is as true of all the other feeding stuffs as of the straw.

The values given to roots and potatoes will probably seem low; but these values are in harmony with the results of extensive feeding experiments, made at this Station. Attention is called again to the fact that turnips and mangels contain a larger percentage of water than does milk, while the relative proportion of protein is much smaller than in milk. They may have a hygienic value, similar to that of fruits and vegetables in human diet, but this has not been demonstrated by experiment.

The market value of oats is much higher than the theoretical value; but the price of oats is governed by the reputation it has made as a food for horses, by its comparatively large use in human food, and by its relative cost of production. While the average price of corn in Chicago has averaged 45 cents per bushel, or 80 cents per cental of shelled grain, that of oats has averaged 30 cents per bushel, or 94 cents per cental. But the average yield of corn in Ohio is about 32 bushels, or 1,792 pounds of shelled grain per acre; that of oats for the 10 years, 1883–92, was 27.73 bushels, or 887 pounds of grain per acre; the actual weight of grain per acre being therefore less than half as much in the case of oats as in that of corn. The average acre of oats in Ohio has therefore been worth, at Chicago prices, $8.32, while that of corn has been worth $14.40, omitting the straw and fodder from the calculation. It is true that the acre of oats may be produced more cheaply than the acre of corn; but the difference in market value here indicated is certainly greater than the difference in cost of production, and oats would hardly be raised, in most parts of Ohio, except for its usefulness in a general system of crop rotation

Among the by-products, the market price of gluten meal and new process linseed oil meal is seen to be very much below their theoretical value, which may be explained by the fact that these are comparatively new feeding stuffs, and farmers have not learned to use them generally. In our feeding experiment, as has been already stated, we found no ground for rating gluten meal lower than old process linseed oil meal. We have not made a thorough comparison of the two kinds of linseed meal, nor of cotton-seed meal.

Finally, it will be observed that this table is simply an attempt to compare animal foods on the basis of their average nutritive constituents, valuing these according to the best data at present attainable; data which it is hoped may be greatly improved upon in the near future. No attempt is made to estimate those factors of final value which are due to relative cost of handling (as between corn fodder and hay), to adaptability to special purposes, or to established prejudices. These factors, as well as the further point that a feeding stuff can only produce its full effect when fed in a ration adjusted to the physiological requirements of the animal, must be kept in mind in the use of the table.

APPENDIX.

The average composition of the principal materials used in feeding animals is shown in Tables XVI and XVII. Table XVI is compiled from tables originally prepared by Professors Jenkins and Winton, of the Connecticut Experiment Station, and revised by Dr. E. W. Allen, of the Office of Experiment Stations, U. S. Department of Agriculture, and Table XVII is given as compiled by Mr. W. H. Beal, of the Office of Experiment Stations. Both tables are intended to show the average composition, as derived from the most trustworthy analyses, American analyses being used wherever practicable.

TABLE XVI.—Average Composition of Feeding Stuffs.

	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses.
GREEN FODDER.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Corn fodder:[1]							
Flint varieties	79.8	1.1	2.0	4.3	12.1	0.7	40
Flint var. cut after kernels had glazed.	77.1	1.1	2.1	4.3	14.6	0.8	10
Dent varieties	79.0	1.2	1.7	5.6	12.0	0.5	63
Dent var. cut after kernels had glazed	73.4	1.5	2.0	6.7	15.5	0.9	7

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[1] Corn fodder is the entire plant, usually a thickly planted crop. Corn stover is what is left after the ears are harvested.

TABLE XVI—Continued.

	Water.	Ash.	Protein.	Fiber	Nitrogen free extract.	Fat.	Number of analyses.
GREEN FODDER—Concluded.	*Per ct*	*Per ct.*	*Per ct*	*Per ct*	*Per ct.*	*Per ct*	
Corn fodder—Concluded:							
Sweet varieties	79.1	1.3	1.9	4.4	12.8	0.5	21
All varieties	79.3	1.2	1.8	5.0	12.2	0.5	126
Leaves and husks, cut green	66.2	2.9	2.1	8.7	19.0	1.1	4
Stripped stalks, cut green	76.1	0.7	0.5	7.3	14.9	0.5	4
Rye fodder	76.6	1.8	2.6	11.6	6.8	0.6	7
Oat fodder	62.2	2.5	3.4	11.2	19.3	1.4	6
Redtop,[1] in bloom	65.3	2.3	2.8	11.0	17.7	0.9	5
Tall oat grass,[2] in bloom	69.5	2.0	2.4	9.4	15.8	0.9	3
Orchard grass, in bloom	73.0	2.0	2.6	8.2	13.3	0.9	4
Meadow fescue, in bloom	69.9	1.8	2.4	10.8	14.3	0.8	4
Italian rye grass, coming into bloom	73.2	2.5	3.1	6.8	13.3	1.3	24
Timothy,[3] at different stages	61.6	2.1	3.1	11.8	20.2	1.2	56
Kentucky blue grass,[4] at different stages	65.1	2.8	4.1	9.1	17.6	1.3	18
Hungarian grass	71.1	1.7	3.1	9.2	14.2	0.7	14
Red clover, at different stages	70.8	2.1	4.4	8.1	13.5	1.1	43
Alsike clover,[5] in bloom	74.8	2.0	3.9	7.4	11.0	0.9	4
Crimson clover	80.9	1.7	3.1	5.2	8.4	0.7	3
Alfalfa,[6] at different stages	71.8	2.7	4.8	7.4	12.3	1.0	23
Serradella, at different stages	79.5	3.2	2.7	5.4	8.6	0.7	9
Cowpea	83.6	1.7	2.4	4.8	7.1	0.4	10
Soja bean	75.1	2.6	4.0	6.7	10.6	1.0	27
Horse bean	84.2	1.2	2.8	4.9	6.5	0.4	2
Flat pea (*Lathyrus sylvestris*)	66.7	2.9	8.7	7.9	12.2	1.6	2
Rape	84.5	2.0	2.3	2.6	8.4	0.5	2
SILAGE.							
Corn silage	79.1	1.4	1.7	6.0	11.0	0.8	99
Sorghum silage	76.1	1.1	0.8	6.4	15.3	0.3	6
Red clover silage	72.0	2.6	4.2	8.4	11.6	1.2	5
Soja bean silage	74.2	2.8	4.1	9.7	6.9	2.2	1
Cowpea vine silage	79.3	2.9	2.7	6.0	7.6	1.5	2
Fieldpea vine silage	50.1	3.5	5.9	13.0	26.0	1.6	1
Silage of mixture of cowpea vines and soja bean vines	69.8	4.5	3.8	9.5	11.1	1.3	1

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[1] Herd's grass of Pennsylvania. [2] Meadow oat grass. [3] Herd's grass of New England and New York. [4] June grass. [5] Swedish clover. [6] Lucern.

TABLE XVI—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER.	*Per ct.*	*Per ct.*	*Per ct*	*Per ct*	*Per ct.*	*Per ct.*	
Corn fodder,[1] field cured	42.2	2.7	4.5	14 3	34.7	1.6	35
Corn leaves, field cured	30.0	5.5	6.0	21.4	35.7	1.4	17
Corn husks, field cured	50.9	1.8	2.5	15.8	28.3	0.7	16
Corn stalks, field cured	68.4	1.2	1.9	11.0	17.0	0.5	15
Corn stover,[2] field cured	40.5	3.4	3.8	19.7	31.5	1.1	60
Hay from:							
Redtop,[3] cut at different stages	8.9	5.2	7.9	28 6	47.5	1.9	9
Redtop, cut in bloom	8.7	4.9	8.0	29.9	46.4	2.1	3
Orchard grass	9.9	6.0	8.1	32.4	41.0	2 6	10
Timothy,[4] all analyses	13.2	4.4	5.9	29.0	45.0	2.5	68
Timothy, cut in full bloom	15.0	4.5	6.0	29.6	41.9	3.0	12
Timothy, cut soon after bloom	14.2	4.4	5.7	28.1	44.6	3.0	11
Timothy, cut when nearly ripe	14.1	3.9	5.0	31.1	43.7	2.2	12
Kentucky blue grass	21.2	6.3	7.8	23.0	37.8	3.9	10
Cut when seed was in milk	24.4	7.0	6.3	24 5	34.2	3.6	4
Cut when seed was ripe	27.8	6.4	5.8	23.8	33.2	3.0	4
Hungarian grass	7 7	6.0	7.5	27.7	49.0	2.1	13
Meadow fescue	20.0	6 8	7.0	25.9	38.4	2.7	9
Italian rye grass	8.5	6.9	7 5	30.5	45 0	1 7	4
Mixed grasses	15.3	5 5	7.4	27.2	42.1	2.5	126
Rowen (mixed)[5]	16.6	6.8	11.6	22.5	39.4	3.1	23
Mixed grasses and clovers	12.9	5.5	10.1	27.6	41.3	2.6	17
Swamp hay	11.6	6.7	7.2	26 6	45.9	2.0	8
Salt marsh	10.4	7.7	5 5	30 0	44.1	2.4	10
Red clover	15.3	6.2	12.3	24.8	38.1	3.3	38
Red clover in bloom	20.8	6.6	12.4	21.9	33.8	4.5	6
Alsike clover	9.7	8.3	12 8	25.6	40.7	2.9	9
White clover	9.7	8.3	15.7	24.1	39.3	2.9	7
Crimson clover	9 6	8 6	15.2	27.2	36 6	2 8	7
Japan clover	11.0	8 5	13.8	24 0	39 0	3.7	2
Vetch	11.3	7.9	17.0	25.4	36.1	2 3	5
Serradella	9.2	7.2	15.2	21.6	44.2	2.6	3
Alfalfa[6]	8.4	7.4	14 3	25.0	42.7	2.2	21
Cowpea	10.7	7.5	16 6	20.1	42.2	2 2	8
Soja bean	11.3	7.2	15 4	22.3	28 6	5.2	6

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[1] Entire plant. [2] What is left after the ears are harvested. [3] Herd's grass of Pennsylvania. [4] Herd's grass of New England and New York. [5] Second cut. [6] Lucern.

TABLE XVI—Continued.

	Water.	Ash.	Protein.	Fiber	Nitrogen free extract.	Fat.	Number of analyses.
HAY AND DRY COARSE FODDER—Concluded.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Hay from—Concluded:							
Flat pea (*Lathyrus sylvestris*)	8.4	7.9	22.9	26.2	31.4	3.2	5
Peanut vines (without nuts)	7.6	10.8	10.7	23.6	42.7	4.6	6
Soja-bean straw	10.1	5.8	4.6	40.4	37.4	1.7	4
Horse-bean straw	9.2	8.7	8.8	37.6	34.3	1.4	1
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3	7
Rye straw	7.1	3.2	3.0	38.9	46.6	1.2	7
Oat straw	9.2	5.1	4.0	37.0	42.4	2.3	12
Buckwheat straw	9.9	5.5	5.2	43.0	35.1	1.3	3
ROOTS AND TUBERS.							
Potatoes	78.9	1.0	2.1	0.6	17.3	0.1	12
Sweet potatoes	71.1	1.0	1.5	1.3	24.7	0.4	6
Red beets	88.5	1.0	1.5	0.9	8.0	0.1	9
Sugar beets	86.5	0.9	1.8	0.9	9.8	0.1	19
Mangel-wurzels	90.9	1.1	1.4	0.9	5.5	0.2	9
Turnips	90.5	0.8	1.1	1.2	6.2	0.2	3
Ruta-bagas	88.6	1.2	1.2	1.3	7.5	0.2	4
Carrots	88.6	1.0	1.1	1.3	7.6	0.4	8
Artichokes	79.5	1.0	2.6	0.8	15.9	0.2	2
GRAINS AND OTHER SEEDS.							
Corn kernel:							
Dent all analyses	10.6	1.5	10.3	2.2	70.4	5.0	86
Flint, all analyses	11.3	1.4	10.5	1.7	70.1	5.0	68
Sweet, all analyses	8.8	1.9	11.6	2.8	66.8	8.1	26
Pop varieties	10.7	1.5	11.2	1.8	69.6	5.2	4
Soft varieties	9.3	1.6	11.4	2.0	70.2	5.5	5
All varieties and analyses	10.9	1.5	10.5	2.1	69.6	5.4	208
Sorghum seed	12.8	2.1	9.1	2.6	69.8	3.6	10
Barley	10.9	2.4	12.4	2.7	69.8	1.8	10
Oats	11.0	3.0	11.8	9.5	59.7	5.0	30
Rye	11.6	1.9	10.6	1.7	72.5	1.7	6
Wheat, spring varieties	10.4	1.9	12.5	1.8	71.2	2.2	13
Wheat, winter varieties, all analyses	10.5	1.8	11.8	1.8	72.0	2.1	262
Wheat, all varieties	10.5	1.8	11.9	1.8	71.9	2.1	310
Rice	12.4	0.4	7.4	0.2	79.2	0.4	10

TABLE XVI—Continued.

	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses.
GRAINS AND OTHER SEEDS—Concluded.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct*	
Buckwheat	12.6	2.0	10.0	8.7	64.5	2.2	8
Sunflowerseed (whole)	8.6	2.6	16.3	29.9	21.4	21.2	2
Cotton seed, whole (with hulls)	10.3	3.5	18.4	23.2	24.7	19.9	5
Cotton-seed kernels (without hulls)	6.2	4.7	31.2	3.7	17.6	36.6	2
Cotton seed, whole, roasted	6.1	5.5	16.8	20.4	23.5	27.7	2
Peanut kernel (without hulls)	7.5	2.4	27.9	7.0	15.6	39.6	7
Horse bean	11.3	3.8	26.6	7.2	50.1	1.0	1
Soja bean	10.8	4.7	34.0	4.8	28.8	16.9	8
Cowpea	14.8	3.2	20.8	4.1	55.7	1.4	5
MILL PRODUCTS.							
Corn meal	15.0	1.4	9.2	1.9	68.7	3.8	77
Corn and cob meal	15.1	1.5	8.5	6.6	64.8	3.5	7
Oatmeal	7.9	2.0	14.7	0.9	67.4	7.1	6
Barley meal	11.9	2.6	10.5	6.5	66.3	2.2	3
Rye flour	13.1	0.7	6.7	0.4	78.3	0.8	4
Wheat flour, all analyses	12.4	0.5	10.8	0.2	75.0	1.1	20
Buckwheat flour	14.6	1.0	6.9	0.3	75.8	1.4	4
Ground linseed	8.1	4.7	21.6	7.3	27.9	30.4	2
Pea meal	10.5	2.6	20.2	14.4	51.1	1.2	2
Soja-bean meal	10.8	4.5	36.7	4.5	27.3	16.2	1
Ground corn and oats, equal parts	11.9	2.2	9.6	....	[1] 72.0	4.4	6
WASTE PRODUCTS.							
Corncob	10.7	1.4	2.4	30.1	54.9	0.5	19
Hominy chops	11.1	2.5	9.8	3.8	64.5	8.3	12
Corn germ	10.7	4.0	9.8	4.1	64.0	7.4	3
Corn-germ meal	8.1	1.3	11.1	9.9	62.5	7.1	6
Gluten meal	8.8	0.8	29.7	2.2	49.8	8.7	54
Recent analyses	8.2	0.9	29.3	3.3	46.5	11.8	20
Chicago[2]	10.1	1.1	30.1	1.6	48.7	8.4	8
Buffalo[2]	8.2	0.8	23.3	6.1	50.4	11.2	5
Cream gluten	8.1	0.7	36.1	1.3	39.0	14.8	3
Gluten feed	7.8	1.1	24.0	5.3	51.2	10.6	11
Buffalo[2]	7.7	1.1	25.0	5.3	49.3	11.6	5
Pope's	14.0	0.6	33.3	1.6	36.5	14.1	1
Peoria[2]	7.5	0.8	19.8	8.2	51.1	12.6	1

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[1] Including fiber.

[2] Included in above average.

TABLE XVI—Concluded.

	Water.	Ash.	Protein.	Fiber.	Nitrogen free extract.	Fat.	Number of analyses
WASTE PRODUCTS—Concluded.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Chicago maize feed	9.1	0.9	22.8	7.6	52.7	6.9	3
Glucose feed and glucose refuse	6.5	1.1	20.7	4.5	56.8	10.4	2
Dried starch feed and sugar feed	10.9	0.9	19 7	4.7	54 8	9.0	4
Starch feed, wet	65.4	0.3	6.1	3.1	22.0	3.1	12
Oat feed	7.7	3.7	16.0	6.1	59.4	7.1	4
Barley screenings	12.2	3.6	12.3	7.3	61.8	2.8	2
Malt sprouts	10.2	5.7	23.2	10.7	48.5	1.7	4
Brewers' grains, wet	75.7	1.0	5.4	3.8	12.5	1.6	15
Brewers' grains, dried	8.2	3.6	19.9	11.0	51.7	5.6	3
Grano gluten	5.8	2.8	31.1	12.0	33.4	14 9	1
Rye bran	11.6	3.6	14.7	3.5	63.8	2 8	7
Wheat bran from spring wheat	11.5	5.4	16.1	8.0	54.5	4.5	10
Wheat bran from winter wheat	12.3	5.9	16.0	8.1	53.7	4.0	7
Wheat bran, all analyses	11.9	5.8	15.4	9.0	53.9	4.0	88
Wheat middlings	12.1	3.3	15.6	4.6	60.4	4.0	32
Wheat shorts	11.8	4.6	14.9	7.4	56.8	4.5	12
Wheat screenings	11.6	2.9	12.5	4.9	65.1	3.0	10
Rice bran	9.7	10.0	12.1	9.5	49.9	8.8	5
Rice hulls	8.2	13.2	3.6	35.7	38.6	0.7	3
Rice polish	10.0	6.7	11.7	6.3	58.0	7.3	4
Buckwheat middlings	13.2	4.8	28.9	4.1	41.9	7.1	3
Cotton-seed meal	8.2	7.2	42.3	5.6	23.6	13.1	35
Cotton-seed hulls	11.1	2.8	4.2	46.3	33.4	2.2	20
Linseed meal, old process	9.2	5.7	32.9	8.9	35.4	7.9	21
Linseed meal, new process	10.1	5.8	33.2	9.5	38.4	3.0	14
Peanut meal[1]	10.7	4.9	47.6	5.1	23.7	8.0	2,480
Peanut hulls	9.0	3.4	6.6	64.3	15.1	1.6	5
MILK AND ITS BY-PRODUCTS.							
Whole milk	87 2	0.7	3.6	....	4.9	3 7	793
Skim milk cream raised by setting	90.4	0.7	3.3	....	4.7	0.9	96
Skim milk, cream raised by separator	90.6	0.7	3.1	....	5.3	0.3	7
Buttermilk	90.1	0.7	4.0	....	4.0	1.1	85
Whey	93.8	0.4	0.6	....	5.1	0.1	46

[1] Mostly European analyses.

TABLE XVII.—FERTILIZING CONSTITUENTS OF AMERICAN FEEDING STUFFS.

	Moisture	Ash.	Nitrogen	Phosphoric acids.	Potash.
GREEN FODDERS.					
Corn fodder	78.61	4.84	0.41	0.15	0.33
Common millet	62.58	....	0.61	0.19	0.41
Hungarian grass (*German millet*)	74.31	....	0.39	0.16	0.55
Orchard grass (*Dactylis glomerata*)	73.14	2.09	0.43	0.16	0.76
Timothy grass (*Phleum pratense*)	66.90	2.15	0.48	0.26	0.76
Mixed pasture grasses	63.12	3.27	0.91	0.23	0.75
Red clover (*Trifolium pratense*)	80.00	....	0.53	0.13	0.46
White clover (*Trifolium repens*)	81.00	....	0.56	0.20	0.24
Alsike clover (*Trifolium hybridum*)	81.80	1.47	0.44	0.11	0.20
Scarlet clover (*Trifolium incarnatum*)	82.50	....	0.43	0.13	0.49
Alfalfa (*Medicago sativa*)	75.30	2.25	0.72	0.13	0.56
Cowpea	78.81	1.47	0.27	0.10	0.31
Soja bean (*Glycine soja*)	73.20	....	0.29	0.15	0.53
Corn silage	77.95	....	0.28	0.11	0.37
HAY AND DRY COARSE FODDERS.					
Corn fodder (with ears)	7.85	4.91	1.76	0.54	0.89
Corn stover (without ears)	9.12	3.74	1.04	0.29	1.40
Common millet	9.75	....	1.28	0.49	1.69
Hungarian grass	7.69	6.18	1.20	0.35	1.30
Hay of mixed grasses	11.99	6.34	1.41	0.27	1.55
Redtop (*Agrostis vulgaris*)	7.71	4.59	1.15	0.36	1.02
Timothy	7.52	4.93	1.26	0.53	0.90
Orchard grass	8.84	6.42	1.31	0.41	1.88
Kentucky blue grass (*Poa pratensis*)	10.35	4.16	1.19	0.40	1.57
Meadow fescue (*Festuca pratensis*)	8.89	8.08	0.99	0.40	2.10
Red clover	11.33	6.93	2.07	0.38	2.20
Mammoth red clover (*Trifolium medium*)	11.41	8.72	2.23	0.55	1.22
White clover	....	....	2.75	0.52	1.81
Scarlet clover	18.30	7.70	2.05	0.40	1.31
Alsike clover	9.94	11.11	2.34	0.67	2.23
Alfalfa	6.55	7.07	2.19	0.51	1.68
Bokhara clover (*Melilotus alba*)	7.48	7.70	1.98	0.56	1.83
Soja bean (whole plant)	6.30	6.47	2.32	0.67	1.08
Soja bean (straw)	13.00	....	1.75	0.40	1.32
Cowpea (whole plant)	10.95	8.40	1.95	0.52	1.47
Barley straw	11.44	5.30	1.31	0.30	2.09
Barley chaff	13.08	....	1.01	0.27	0.99
Wheat straw	12.56	3.81	0.59	0.12	0.51

TABLE XVII—Continued.

	Moisture	Ash.	Nitrogen	Phosphoric acid.	Potash.
HAY AND DRY COARSE FODDERS—Concluded.					
Wheat chaff	8.05	7.18	0.79	0.70	0.42
Rye straw	7.61	3.25	0.46	0.28	0.79
Oat straw	9.09	4.76	0.62	0.20	1.24
ROOTS, BULBS, TUBERS, ETC.					
Potatoes	79.75	0.99	0.21	0.07	0.29
Red beets	87.73	1.13	0.24	0.09	0.44
Sugar beets	86.95	1.04	0.22	0.10	0.48
Mangel-wurzels	87.29	1.22	0.19	0.09	0.38
Turnips	89.49	1.01	0.18	0.10	0.39
Ruta-bagas	89.13	1.06	0.19	0.12	0.49
Carrots	89.79	9.22	0.15	0.09	0.51
GRAINS AND OTHER SEEDS.					
Corn kernels	10.88	1.53	1.82	0.70	0.40
Sorghum seed	14.00	....	1.48	0.81	0.42
Barley	14.30	2.48	1.51	0.79	0.48
Oats	18.17	2.98	2.06	0.82	0.62
Wheat (spring)	14 35	1.57	2.36	0 70	0.39
Wheat (winter)	14.75	....	2.36	0 89	0.61
Rye	14.90	....	1.76	0.82	0.54
Common millet	12.68	....	2.04	0.85	0.36
Soja beans	18.33	4.99	5.30	1.87	1.99
MILL PRODUCTS.					
Corn meal	12.95	1.41	1.58	0.63	0.40
Corn and cob meal	8.96	....	1.41	0.57	0.47
Ground oats	11.17	3.37	1.86	0.77	0.59
Ground barley	13.43	2.06	1.55	0.66	0.34
Rye flour	14.20	....	1.68	0.85	0.65
Wheat flour	9.83	1.22	2.21	0.57	0.54
Pea meal	8.85	2.68	3.08	0.82	0.99
BY-PRODUCTS AND WASTE MATERIALS.					
Corn cobs	12.09	0.82	0.50	0.06	0.60
Hominy feed	8.93	2.21	1.63	0.98	0.49
Gluten meal	8.59	0.73	5.03	0.33	0.05
Starch feed (glucose refuse)	8.10	....	2.62	0.29	0.15
Malt sprouts	10.38	12.48	3.55	1.43	1.63
Brewers' grains (dry)	6.98	6.15	3 05	1.26	1.55
Brewers' grains (wet)	75.01	....	0.89	0.31	0.05
Rye bran	12.50	4.60	2.32	2.28	1.40

TABLE XVII—Concluded.

	Moisture	Ash.	Nitrogen	Phosphoric acid.	Potash.
BY-PRODUCTS AND WASTE MATERIALS—Concluded.					
Rye middlings	12.54	3.52	1.84	1.26	0.81
Wheat bran	11.74	6.25	2 67	2.89	1.61
Wheat middlings	9.18	2.30	2.63	0.95	0.63
Cotton-seed meal	9.90	6.82	6.64	2.68	1.79
Linseed meal (old process)	8.88	6.08	5.43	1.66	1.37
Linseed meal (new process)	7.77	5.37	5.78	1.83	1.39
Apple pomace	80.50	0.27	0.23	0.02	0.13

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SUB-IRRIGATION IN THE GREENHOUSE.

BY W. J. GREEN AND E. C. GREEN.

I. CONSTRUCTION OF GREENHOUSE BEDS AND BENCHES FOR SUB-IRRIGATION.

A water-tight bed, or bench bottom, is necessary in sub-irrigation, and there are several methods by which this may be secured.

Our first attempt was made with matched lumber or flooring, the joints being filled with white lead. The objection to this method of construction is partly on account of the cost, but more particularly because of the fact that when the boards swell the bottom bulges upward, displacing the irrigating tile and causing leakage.

It has been found that common barn boards, or any rough lumber, answeres better, if the cracks are battened with lath, and a layer of cement is spread over the entire bottom, deep enough to almost cover the lath. About one-third of good cement and two-thirds sand, made quite thin with water, spread on to the depth of about half an inch, and not allowed to dry too quickly, answers the purpose very well. The bottom boards will last longer than when the soil is placed directly upon them, but the supports underneath need to be somewhat nearer together than in the ordinary method of construction, so as to prevent springing of the boards, which cracks the cement.

The greatest difficulty is found in making the sides of the benches water-tight, as no matter how well the side boards are nailed to the bottom boards, they will spring away and cause leakage. To obviate this the cement needs to be put on more thickly at the sides, bringing it up against the side boards two or three inches high, and from one to two inches thick. In fact the office of the cement is to hold the water, while the side boards protect the cement and retain the soil.

In case it is desired to make a bed on the ground the bottom may be constructed in the same manner as an ordinary cellar bottom, except that the cement need not be as thick. Sometimes the bottom may be made directly on the clay sub-soil, or clay may be brought in for the purpose and no cement used. There may be some leakage in a clay bottom, but not sufficient to do any harm. In all cases there must be a level bottom, or at least the slope must be slight, and all in one direction. Inequalities in the bottom will prevent the proper working of the irrigating tile and result in unequal distribution of the water, hence a perfect grade is essential. In case benches are constructed, the best plan is to use indestructible material altogether.

The interior of one of the houses at the Station, with the bench supports ready for the tile bottom, is shown in Fig. I.. It will be seen that the iron gas pipe posts, upon which the purlines rest, support the benches as well as the roof. These posts are of 1¼-inch gas pipe, eight feet apart, a row along each side of the walks and one row through the middle, making five rows in all. There are additional posts between these which reach to the tops of the benches only, making the bench posts four feet apart. To these posts are fastened, by means of clips, 1½-inch gas pipe, laid horizontally, at the proper height for the bench bottoms. The clips are of ⅛-inch strap iron, held with stove bolts, and are quite as good as the more costly cast iron clips. Upon the horizontal gas pipes are laid the T iron supports for the tile bottoms. In this case the supports for the tile are of cast iron, and differ from the ordinary T iron in having the lower flange wider in the middle than at the ends, a lip cast at the ends to hold the bench sides in place, and a concave to rest upon and brace the horizontal pipe supports.

Fig. II shows the same house with the tile bottoms, and sides of the benches ready for the cement and irrigating tile. In this case the tiles are 8 x 12 inches, but any desired size may be used. Tiles of this description are not found in the market generally, but were made by A. Brandstetter, Wooster, O., by dividing hollow brick, which are 4 x 8 x 12 inches, as they came from the molding machine. These are cheaper than the tiles ordinarily used for this purpose, and quite as good as those specially designed for greenhouses. Another form 12 x 24 inches in size is made by the H. B. Camp Co., of Greentown, O. This has the advantage of requiring less cross bars than the other form. Ordinary drain tiles answer very well, but those with six sides are preferred, as if they do not quite fit, when laid side by side, they may be turned so that the angles, or points, touch. Thus when a row is laid across the bench it may be lengthened or shortened, by simply turning some of the tiles. It makes but little difference in the cost, whether large or small tiles are used, but the small sized tiles, usually 2-1½-inch, are preferred, as they take up less space and do not require as wide bench sides.

The sides of the benches are of ordinary roofing slate, 7 x 24 inches in size, and were made by cutting 14 x 24-inch slates in two lengthwise. These slates are held in place by galvanized iron caps, on both top and bottom, and are shown in Figs. II and III. The slate sides rest upon the ends of the cast iron supports for the tile, and are held in place at the bottom by the lips above referred to, and at the top are fastened to the posts with copper wire.

Fig. III shows the same house with the bench bottoms cemented, and the irrigating tiles laid, ready for the soil. The cementing is done in the same manner as described for wooden benches, and it is necessary to bring the cement well up against the sides, as at this point the leakage is most likely to occur, although the slate sides do not spring outward in the same manner as board sides.

The irrigating tiles may be laid lengthwise or crosswise the beds, but about fifty feet is the greatest length of tile that will work satisfactorily on a level, and if the runs are to be longer than this, there should be one or two inches fall to each fifty feet. It will be necessary, however, in case there is a fall, to check the water at intervals, in order to prevent a too rapid flow towards the lower end. This may be easily done by inserting strips of tin into the joints as often as need be, so as to partially intercept the flow, and to cause the water to run out at the joints wherever needed. When properly laid, rows of tile several hundred feet in length could be made to work satisfactorily, but we have had the best success with short runs of tile, laid crosswise the benches. Instead of using elbows of sewer pipe as shown in the cut a cheaper plan is to employ common tile altogether. In this case, the end of the outer tile is raised so as to come above the top of the bench, in order to admit of inserting the hose in watering. When the tiles are laid crosswise the benches, several may be watered at once by means of a piece of gas pipe with holes bored at suitable distances. When the tiles are laid, they are simply placed end to end, and no cement is needed, although it is sometimes used, to prevent the tiles becoming displaced in filling the benches with soil.

Gas pipe, with holes bored at intervals, has been used with success, also a pipe, called "structural iron pipe." This differs from ordinary iron pipe in having a slot along one side. Where the slot is nearly closed, so as to not allow the water to flow too freely, this pipe answers very well, but 2½-inch drain tiles are cheaper than anything else and are perfectly satisfactory. These tiles are, of course, removed and put in place again, each time the soil in the benches is renewed Another thing in favor of 2½ or 3-inch tiles, is that the capacity is sufficient, so that it may be filled quickly and the operator may go on to another tile, allowing the water to soak out into the soil, knowing that enough has been given to last several days; but if iron pipes are used the size must be small because of the cost, and the watering must be more frequent in consequence.

II. HISTORY OF SUB-IRRIGATION IN THE GREENHOUSE.

The first suggestion of sub-irrigation in the greenhouse was made by E. C. Green and W. S. Turner, assistants in the horticultural department, and grew out of an attempt to prevent the lettuce rot. A few lettuce plants were set in a box, in which a tile was so placed as to admit of watering, without wetting the foliage, the purpose being to test the theory that wetting the foliage induces or favors the development of rot. The lettuce in the boxes grew so finely that the experiment was enlarged, in order to test the effect of that method of watering on the growth, as well as to determine the relation of sprinkling the foliage to the health of the plants.

The further development of the plan is due to the combined efforts of the Horticulturist and assistants, E. C. Green and W. S. Turner. The experiments were begun in 1890 and carried on two years in the greenhouses first built by the Station and now occupied by the horticultural department of the State University. The removal from Columbus to Wooster caused a suspension of the work one year by the Station, although Mr. Turner who remained as foreman in the horticultural department of the University, repeated the experiments on a somewhat larger scale, the results of which have been published in various periodicals by Professor W. R. Lazenby and others. These experiments were first mentioned in the annual report of this Station for 1891, and a report of progress was made in Bulletin 43, September, 1892, and again in the annual reports for 1893 and 1894.

In Bulletin 33, of the West Virginia Station, Professor F. W. Rane gave an account of his experiments in the same line.

The Horticulturist of this Station has prepared a chapter on sub-irrigation in the greenhouse, for a work on greenhouse management by Professor L. R. Taft, and has made brief mention of the progress of the work in the proceedings of both the State and Columbus horticultural societies. A newspaper bulletin was prepared early last season, giving brief instructions as to the method of construction of benches for the purpose, but there have been numerous calls for further information on the subject, both as to results of experiments with various crops, and methods of operation.

The literature of the subject, which is comprised in the publications named above, except a few short newspaper notices, is not only scattered, but is incomplete as to details, hence it seems best to make another report of progress, especially since it may take some time to bring the experiments to a satisfactory state of completion, although enough is already known to warrant giving the facts to the public.

It was with some degree of hesitancy that the first results were announced, as it was thought that in some cases, at least, bad effects might follow sub-irrigation. According to accepted theories, plants could not long continue to thrive when watered by this method, since no provision is made for bench drainage, and for this reason the publication of results has been somewhat delayed. Now that the matter is better understood, fears on this score seem to be groundless, hence there is no longer any doubt as to the propriety of giving out the results and recommending the practice. The belief that bench drainage is essential gave birth to these fears, but that it is not essential in sub irrigation has been fully demonstrated.

It has been feared also that in sub-irrigated houses the air might be so dry that plants would not thrive, and that the red spider would find such conditions very favorable for rapid multiplication. The relative humidity of sub irrigated and surface watered houses has not been determined, but some preliminary experiments fail to show any decided difference, besides we have seen no suffering of the plants because of insufficient moisture in the air.

Nearly entire houses, where vegetables were grown, have been devoted to sub-irrigation for a sufficient time to show that the anticipated danger does not exist, so far as they are concerned, but the test has not been so complete with flowering plants.

With vegetables, no attention has been given to the red spider, as it is not particularly troublesome on such plants, and with florist's stock the usual plan of syringing the foliage has been followed, but that the red spider is worse in sub-irrigated than in surface watered houses we cannot, at present, either affirm or deny.

That the watering of the surface of the soil, incident to the necessary syringing, detracts from the effect of sub-irrigation is admitted, however. For this reason sub-irrigation may prove to be of greater value to vegetable growers than to florists, but our experiments have progressed sufficiently far to show that it is the best method of watering in all cases, where plants are grown in beds or on benches.

The importance of sub-irrigation in the greenhouse is sufficient to warrant a full discussion of the subject, but the results with some of the crops which may be grown by this method must be reserved for a future bulletin. To facilitate a clearer statement of the case some general propositions will first be offered, after which the results with special crops will be discussed.

III. GENERAL PROPOSITIONS REGARDING SUB-IRRIGATION IN THE GREENHOUSE.

(1.) *Watering by sub-irrigation in the greenhouse is more cheaply done than by the ordinary method:* Watering by this method saves both labor and water, but in most cases the first item alone is worth considering As explained in another connection, the rows of irrigating tile are laid two and one-half feet apart on the benches, thus making it possible to water a strip of the bed of the above width, and of whatever length the row of tile may happen to be, equivalent in some cases to 100 square feet or more, without the operator changing position. It is possible, however, for one person to attend to several rows of tile at the same time, and to thoroughly water a house 20 x 100 feet in half an hour. This is not only less time than the same space could be watered in the ordinary manner, but the watering needs to be done less frequently. The saving of labor depends almost wholly upon the completeness of the arrangements for watering, and no doubt in large establishments this saving might be carried much farther than now seems to be possible, even to the extent of reducing the cost of watering to less than one-fifth of the present necessary outlay.

The arrangement is really self regulating, after the hose is inserted into the tile, as the water simply runs out through the joints of the tile and permeates the adjacent soil, thus requiring no care on the part of the operator in its distribution. An inexperienced hand can do as good work as the most expert, as he need give no heed to the work, further than to insert the hose and withdraw as soon as the tile is filled, thus making it possible to employ cheap labor.

(2.) *Watering by sub-irrigation in the greenhouse is more efficiently done than by the ordinary method:* When plants in beds are watered by pouring water on the surface of the soil, much care is required to make the distribution perfect, as well as to give the requisite quantity. Attention to detail is necessary in the first and a thorough knowledge of the needs of plants in the second. Should the knowledge be wanting, or the details be omitted, bad effects are sure to follow, and the damage is not easy to repair.

If insufficient water is given at first the bottom soil is apt to become dry and hard, a condition not easy to remedy, even by excessive watering in the future. Such a state of affairs cannot occur with sub-irrigation, if the beds are properly constructed, nor can there be any dry spots in the beds.

Excessive watering on the surface produces a condition not less objectionable, which will be referred to more particularly in another place, but in this connection it may be said that plants do not suffer from too much water in the soil when the excess is below and the surface is loose and friable, as when these conditions are reversed. That is, a water logged condition of the soil is less likely to occur by sub- than by surface irrigation, and by the first named method the water is put where it is most needed, and where it can do the least harm, in case too much is applied for the present needs of the plants. A reasonably careful man, with almost no experience, can do better work in watering plants by sub-irrigation than the most skillful can by the ordinary method.

With the lettuce crop, the difficulty of watering becomes greater as the plants increase in size. If the foliage is sprinkled it is kept constantly wet, thus favoring the development of the rot, and if the hose is inserted between the plants, more or less injury is done them, besides the surface of the soil becomes puddled where the hose is pushed back and forth. When the plants reach maturity it is a difficult matter to give them as much water as they need, as the soil has become so compacted as to prevent free and uniform percolation. By sub-irrigation the water can be given as easily in the last stages of growth as the first, and in any quantity desired, with full assurance that it will be distributed evenly.

(3.) *Where sub-irrigation is practiced in the greenhouse the soil does not become compacted as by surface watering, but retains its original loose, friable condition, even without frequent stirring, nor does it become mossy, water logged and sour:* This applies more particularly to soil having a considerable per cent. of clay, but the same is, in a measure, true of all classes of soill. With some classes of plants the foliage must be syringed to keep the red spider in check, and in this manner the soil is watered more or less, causing a crust to form on the surface, which must be broken by digging; but the compacting of the soil is directly proportioned to the quantity of water applied to the surface. No matter how frequently the soil is stirred, where surface watering is practiced, it cannot be kept in as good condition as where sub-irrigation is followed, and by the latter method the working of the soil is made comparatively easy.

Examination of sub-irrigated beds shows that the surface of the soil is loose and friable, becoming firmer below, where it often appears to be somewhat soggy. This latter condition disappears as the soil dries out, and hardening does not occur. The soil may be worked at any time without danger of making it hard, as the surface is always comparatively dry, unless the watering has been excessive a short time before. We have found that soil which contains so much clay as to be unfit for use in the greenhouse, where surface watering is practiced, answers very well for sub-irrigation.

(4.) *Plants are less liable to suffer from overwatering and diseases by sub-irrigation than where the water is applied to the surface:* The possibility of overwatering by sub-irrigation may be tentatively admitted, but in practice we have not found the limit to the quantity of water which may be safely used. The quantity applied at one time may be in excess of the needs of the plants for several days and no harm will follow. We have never injured a plant by this method of watering, nor have we seen any symptoms of ill health which plants often exhibit when watered too profusely and frequently on the surface of the soil. In practice we have used water liberally, and have been surprised to note the quantity, not only which may be used without injury to the plants, but which seems to be necessary for the best results.

Whether to water sparingly, but frequently, or less often and profusely, has not been determined, but no bad results appear to follow when the beds are saturated and then allowed to remain several days and to become partially dry before another application is made.

We have found that sub irrigation is not only safer than surface watering, but that, on clay soil at least, it is the only method by which plants can be given all the water they require. Plants will thrive on less water by sub- than by surface irrigation, but they will also use much more, if it is applied, hence the greater possibility of forcing growth by the former than by the latter method. More attention has been given to comparative growth, on surface and sub-irrigated plots, than to relative prevalency of diseases; but lettuce rot has shown a preference for surface watered plants, in some cases in quite a marked manner. The injury done to roses by nematodes has been much greater where the plants were surface watered than where sub-irrigated. Where the latter method has been practiced the plants have almost outgrown the disease, but have succumbed where surface watered.

(5.) *All classes of plants which may be grown upon greenhouse benches thrive better by sub-irrigation than by the ordinary method of watering:* The demonstration of this proposition will be found under the head of results of experiments, but it will not be out of place to assign some reasons which appear to be valid, although not offered as a full and sufficient explanation.

No doubt the physical effect of sub-irrigation upon the soil, which has been referred to, has an important bearing upon the matter, for it is well known that the more porous and friable the soil can be kept the better it is for the plants growing in it. Vegetable matter is often added, and rotted sod is used for the purpose, as well as sand and cinders. It is true that sub-irrigation does not produce this loose, friable condition of the soil, but simply helps to retain or to preserve it, thus making continuous aeration of the soil possible.

The mere presence of the tile in the beds has been supposed to have some beneficial effect in promoting aeration, but when placed in surface watered beds they have not appeared to have any effect. More or less air enters the soil through the tile, along with the water, but the surface of the soil offers a much greater area of exposure, and being more permeable than the lower portions it follows that aeration takes place mostly from above.

In the light of well known facts regarding soil aeration it can hardly be disputed that sub-irrigation is in this manner beneficial, but there are other potential factors. Uniformity and constancy in the supply of moisture to the roots of plants are favorable to growth, and these conditions are assured with sub-irrigation. That plants grown by sub-irrigation take up more water than those watered in the ordinary manner may be inferred from the fact that they grow faster and have a greater leaf development.

It has been urged against this method of watering that unless sprinkling is resorted to undue dryness of the air will result, but it is by no means certain that such a condition occurs, and if so it has not been shown to be detrimental. Plants thrive in arid regions where the air is dry, if water is supplied to the roots; moreover, we have some excellent experimental testimony which ought to set at rest all such fears.

The Botanist of this Station, A. D. Selby, has called attention to and kindly translated the following extract from Frank's *Krankheiten der Pflanzen*, page 310:

> "The nutrition and production of plants are diminished in an atmosphere constantly moist. This depends upon the fact that in air saturated with water vapor the plants cease to transpire. But the stream of transpiration water that goes through the plant is the medium in which the food materials from the soil are conducted into the plant, because precisely these enter into the plant dissolved in this water, but remain behind in it when the plant again gives off pure water in vapor form and thereby makes room to take up a corresponding quantity of new food materials from the soil. In tobacco plants the diminished production of mineral constituents, as well as organic plant constituents, in consequence of suppressed transpiration, has been observed, the plants whose transpiration was obstructed, furnishing, in comparison with those under otherwise the same condition, but with unhindered transpiration, less mineral matter, less nicotine, oxalic acid, citric acid, malic acid, pectose, cellulose and protein, but, on the other hand, much starch. It appears to follow from this that the suppressed transpiration has as a consequence a diminished introduction of mineral matter from the soil, but does not hinder the formation of starch grains in the leaves from carbon dioxide and water. Therefore only the production of those plant constituents is influenced to whose origination constituents of the soil food materials are required."

The greater leaf development of sub-irrigated plants indicates that they transpire more water than those that are surface watered, but the method of watering the latter may be the means of introducing more water into the air than is really needed by the plants, and the efforts of gardeners to produce a moist air in the greenhouse may often be misdirected. It has been demonstrated by the author above quoted that plants have become "drawn" in an over moist atmosphere, and other ill effects follow also, such as dropping the lower leaves, etc. Regarding the general statement of the proposition we have yet to find any exceptions. Sub-irrigation may not be the best method of watering all classes of plants, because of practical difficulties in some cases, but the fact remains that we have found no plants that do not thrive better by this than by the ordinary method of watering. Our experiments have included plants most commonly grown on greenhouse benches, such as lettuce, radishes, cucumbers, tomatoes, spinach, parsley, cauliflower, beets, sweet peas, smilax, roses, gladioli, carnations, violets, chrysanthemums and ferns. As might be expected, these are not all benefited in the same degree by sub-irrigation, but all are improved by it, and sufficiently to warrant its use wherever practicable.

IV. THE RESULTS OF EXPERIMENTS IN SUB-IRRIGATION.

The results of experiments which follow in this and succeeding bulletins may be regarded as the demonstration of proposition five. The full results may not be ready for some time but will be given out as soon as possible.

LETTUCE.

The first experiments in sub-irrigation, as before stated, were with lettuce plants, grown in boxes about 16 inches square, and with about 10 inches of soil. These boxes were water-tight, and in order to obviate the necessity of wetting the foliage of the plants, a 2½-inch drain tile was placed in an upright position, in each box, so that the plants could be supplied with water by simply pouring it into the tile and allowing it to percolate through the soil. The leaves of the plants were not watered, nor was the surface of the soil.

The object of the experiment was simply to test the theory that wetting the foliage is favorable to the development of lettuce rot, hence care was taken to supply water to the roots only.

Because of the belief that drainage is necessary for plants growing in pots, boxes or beds, it was with some surprise that the plants were not only found to do as well by this method of watering as by the one ordinarily practiced, but even better. There was a gain of weight in favor of the sub-irrigated plants equal to 25 per cent.

Experiments on a larger scale were planned at once, and a bed $7\frac{1}{2}$ x 10 feet was prepared on the ground, and another of the same dimensions in the center of the middle bench in one of the houses. Sections of the same bench were reserved on either side for surface watering. The bottom of this bench was made water-tight by laying matched flooring in white lead. $2\frac{1}{2}$-inch drain tiles were laid two and one-half feet apart crosswise the benches, and holes were bored through the sides to admit the hose in watering. The usual quantity of soil was then placed on the bench and the plants set out. The first trial of the beds was even more in favor of sub-irrigation than in the boxes.

The second season another section was taken in the house alongside the first, also some portions of the side benches. The result in every case was in favor of sub-irrigation, the highest gain being 100 per cent. above surface watering. In these experiments there was a very uniform stand and growth of plants in both plots, but those in the sub-irrigated beds stood about twice as high as the others and the weight was double. In order to illustrate the difference, two plants were taken, one from the sub-irrigated bed weighing 10 ounces, and the other from the surface watered bed weighing five ounces, and photographed. These were representative plants from the respective beds, being as fair an average as could be taken, and are shown in Fig. IV.

It may be admitted that plants quite as large can be grown by surface watering, as 10 ounces has often been exceeded, but a longer time is required in which to do it.

It should be here explained that all of the weights given of lettuce are of the fresh plants, as soon as cut, and before washing. It is customary to wash lettuce before weighing, when it is sold by weight, according to the practice in some markets, and had this plan been followed the weighings would have been much heavier, but as this would have been a source of variation and error, it was thought better to follow the plan named. In some trials the results were not so marked, but in all cases there was a decided gain in favor of sub-irrigation, but as these earlier results agree with those obtained recently, it is not necessary to give them in detail. In one sub-irrigated bed the gain in a single crop was sufficient to pay the cost of putting in a new bench bottom, counting the value of the crop at 15 cents per pound, but in all cases the outlay for reconstruction was more than reimbursed the first season. In constructing the houses at Wooster nearly all the benches were made water-tight for sub-irrigation, and only a small part was left for surface watering, the reverse of the plan at Columbus. Three houses, each 20 x 100 feet, have been devoted almost wholly to lettuce, nearly all of which has been sub-irrigated. A middle section in each house has been reserved for surface watering and the end benches are divided, half being watered by one method and half by the other. Incidentally, this arrangement may be referred to as affording an opportunity to note the behavior of plants in houses where the moisture in the air, in addition to the normal quantity, comes almost wholly from plant transpiration.

In the following table the results with a number of varieties are given. This was not intended as a variety experiment, as those in the list are not comparable in the manner presented, since some are varieties which form heads while others do not. All that it is intended to show is the relative development of each variety by the two methods of watering. In this experiment each lot was carried through the entire season of growth by the method indicated That is, the sub-irrigated plants were treated in that manner from the time the seed was sown until the crop was harvested. The particular method of operation is described more fully under the head of cultural notes. The surface watered plants, on the other hand, were surface watered during their entire season of growth. This is referred to particularly because it is not the plan which has been followed in the greater number of our experiments. It will be seen that the average gain in favor of the sub irrigated plots was about 100 per cent.

TABLE I.—THE RESULTS OF SURFACE AND SUB-IRRIGATION WITH TEN VARIETIES OF LETTUCE.

Variety.	Surface watered.		Sub-irrigated.	
	Number of plants.	Weight.	Number of plants.	Weight.
		Ounces.		*Ounces*
Chicago Forcing	5	11	5	22
Denver Market	5	8	5	12
Tilton's White Star	5	11	5	32
Henderson's N. Y.	10	22	10	40
Hanson	10	18	10	48
Grand Rapids	25	80	25	208
Iceberg	15	32	15	47
Big Boston	15	21	15	51
Large Boston	10	14	10	31
Rawson's Hot House	15	23	15	41

In Table II the separate results of 15 experiments are given. It is not necessary to discuss these results in detail for they agree in the main, although there is some variation, as might be expected, owing to the varying circumstances under which the experiments were conducted—early and late in the season, in different houses and by different men—nor would it add to the force of the argument to give a greater number of examples. No effort has been made to select examples, further than to secure a fair average, rather than to present the highest or the lowest. The average gain of the sub-irrigated over the surface watered in the above cases was a little more than 40 per cent. This increase in weight was made in a little more than six weeks, or from the time the plants were set in the benches to the end of the experiments. That is, all of the plants were sub-irrigated while growing in the flats, or during about half of their period of growth, and not until they were planted in the benches was surface watering commenced. This is a less favorable showing for sub-irrigation than is made in Table I, by the plan above described of carrying the plants through their entire period of growth by the respective methods of watering.

TABLE II.—Results in Fifteen Sub-irrigation Experiments With Grand Rapids Lettuce.

Experiment.	Surface watered.		Sub-irrigated.	
	Number of plants.	Weight.	Number of plants.	Weight.
		Ounces.		Ounces.
I	140	474	140	637
II	100	374	100	512
III	75	287	75	383
IV	100	299	100	453
V	55	297	55	340
VI	100	545	100	602
VII	25	132	25	176
VIII	25	121	25	130
IX	35	212	35	242
X	150	477	150	572
XI	107	554	107	644
XII	144	262	144	337
XIII	32	107	32	147
XIV	96	280	96	380
XV	160	156	160	452

In the above examples the surface and sub-irrigated plots were side by side, but a more satisfactory plan is to alternate the plots. This, however, cannot be extended very far, as the difference in heat in the two ends of a house is considerable. A very good plan is to take a section of a bed in the middle of a house and treat by one method of watering, while two sections of the same size on either side are treated according to the other method. This has been done in several cases and some examples are given in Table III. In these experiments the plants were treated in the same manner as those in the experiments above mentioned, *i. e.*, all were sub-irrigated until they were planted in the benches. After that time Sections A and C were sub-irrigated, and Section B was surface watered. The average gain of the sub-irrigated plots over the surface watered was about 38 per cent., or very nearly the same as average of the 15 experiments in Table II.

TABLE III.—Comparison of Surface Watered Sections With Sub-irrigated Sections on Either Side, 75 Grand Rapids Plants in Each Section.

	Section A, sub-irrigated.	Section B, surface watered.	Section C, sub-irrigated.
Experiment I	Weight, 385 ounces	Weight, 325 ounces	Weight, 420 ounces
Experiment II	" 487 "	" 329 "	" 496 "
Experiment III	" 308 "	" 229 "	" 345 "

In all of the experiments thus far referred to, but one point has been considered, and that is the increase in weight by sub-irrigation. Aside from the relative prevalency of disease in plants treated by the two methods, there are but few practical questions.

Although not a matter of much practical importance, some interest attaches to the fact that sub-irrigated lettuce is earlier than that grown in the ordinary manner. It does not really come to maturity any earlier, if by that is meant the stage at which the plants cease to increase in weight, caused by the dying of the lower leaves, but it does reach a marketable size sooner. It is customary to allow the plants to stand as long as they continue to improve, but in case it is desirable to cut before that time it will be found that the sub-irrigated lettuce will be a week to ten days ahead of the other.

Should the size to which surface watered lettuce can be grown be set as a standard, and the sub-irrigated cut when it reaches that size, it will be found that the latter will be ready four to six weeks from the time of planting in the beds, and the surface watered must be allowed to remain from six to eight weeks to attain the same size. Whether we reckon in this manner, or by the actual weight of the crops harvested during the season, there is a gain in one season of about one crop by sub-irrigation. Both the yield and price vary, of course; but for a house 20 x 100 feet the difference in a single season between surface and sub-irrigation might safely be estimated at from $50 to $ 00. The latter figure might not be reached, except on very heavy clay soil, and on soil specially adapted to lettuce the difference might be even less than the lowest, but experience has shown that it is more likely to exceed than to fall below $50.

The difference is likely to be greater with new beginners than with those of experience, as more skill is required to manage a crop by surface

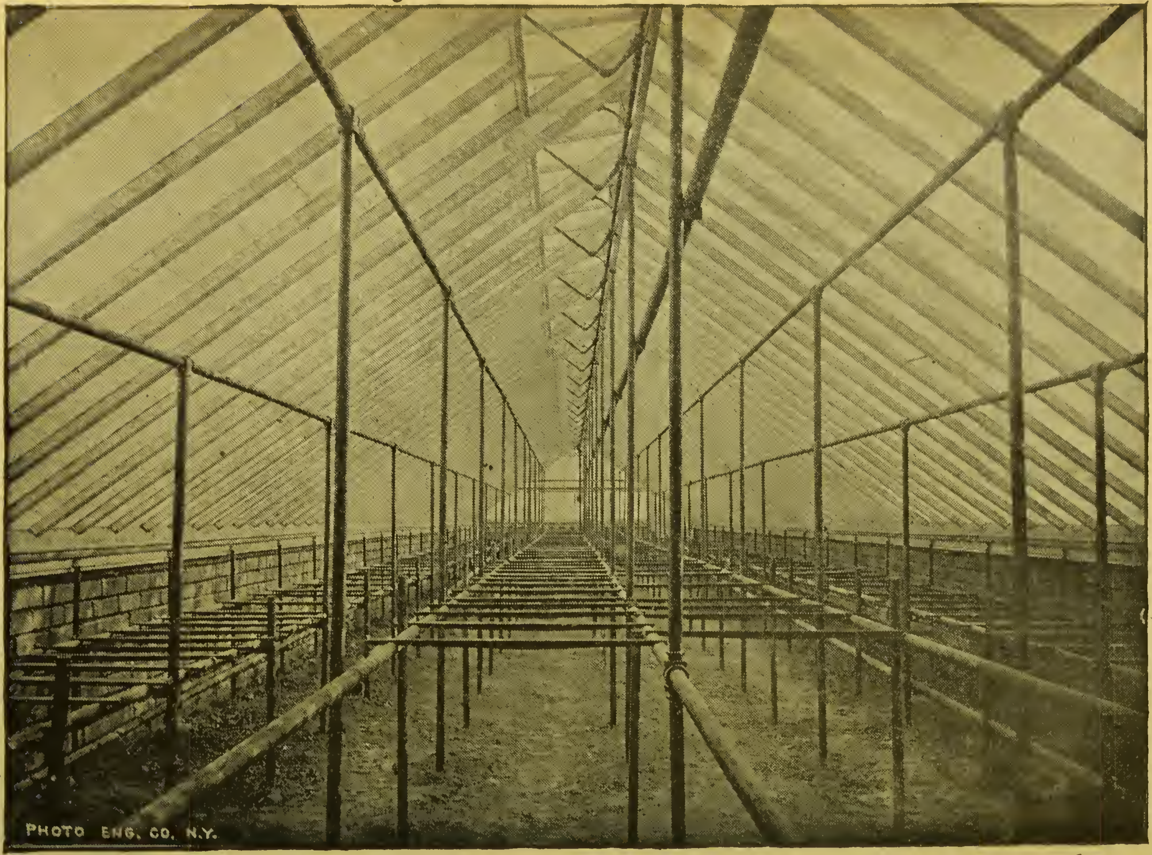

FIG. I.—INTERIOR OF GREENHOUSE, SHOWING IRON SUPPORTS READY FOR BENCH TILE.

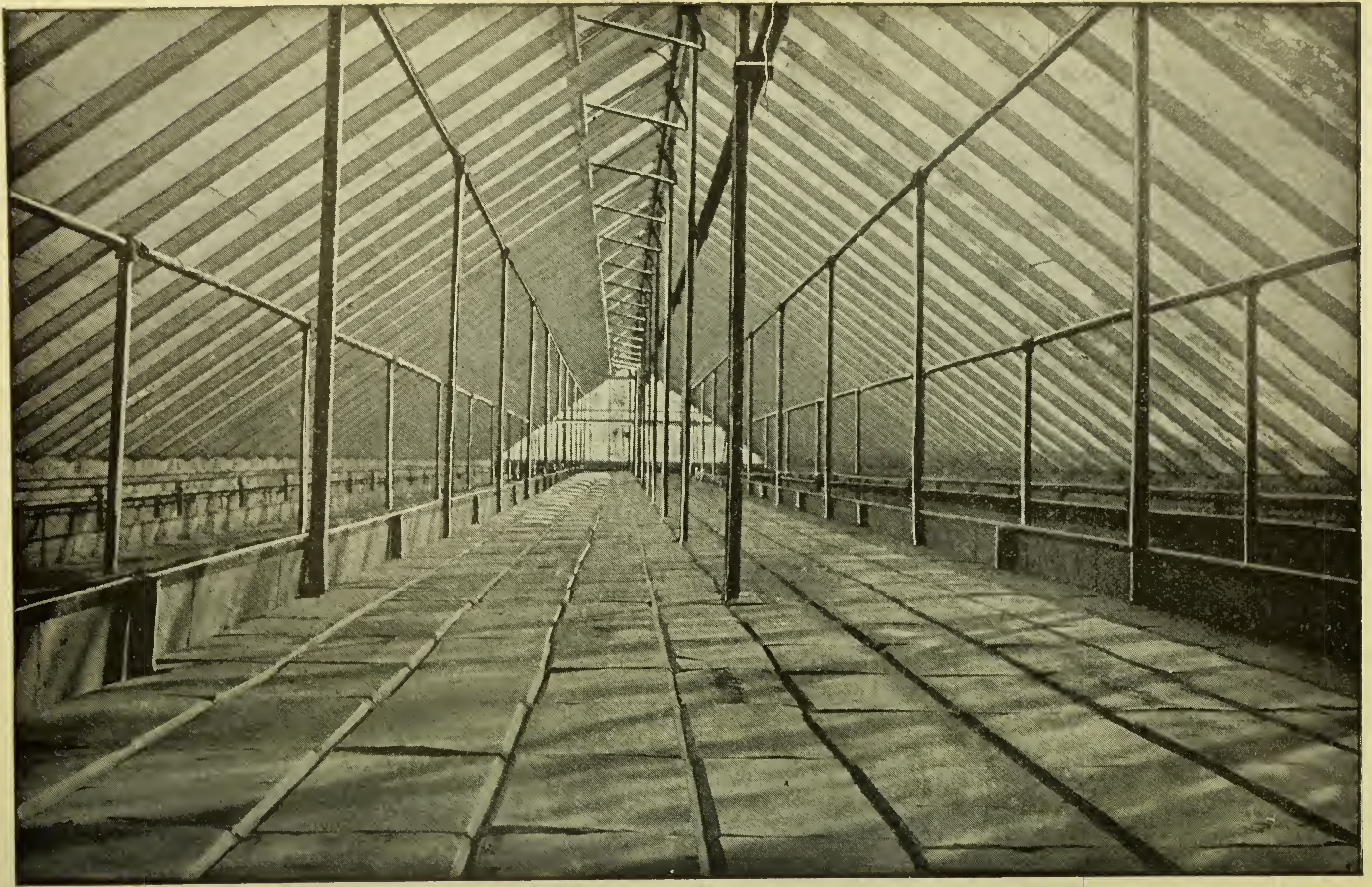

FIG. III.—INTERIOR OF GREENHOUSE, SHOWING TILE BOTTOMS AND SLATE SIDES TO BENCHES.

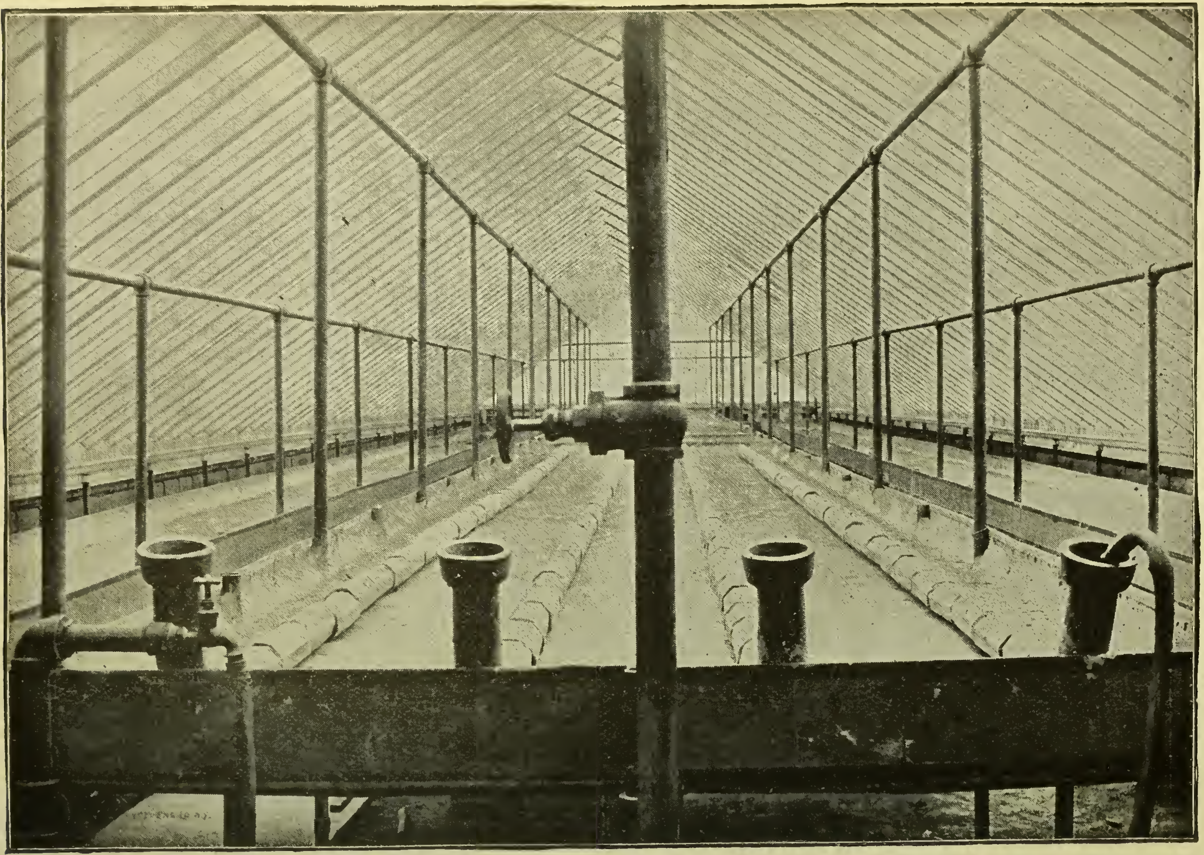

FIG. III.—INTERIOR OF GREENHOUSE, SHOWING BENCHES WITH BOTTOMS CEMENTED, AND IRRIGATING TILE LAID.

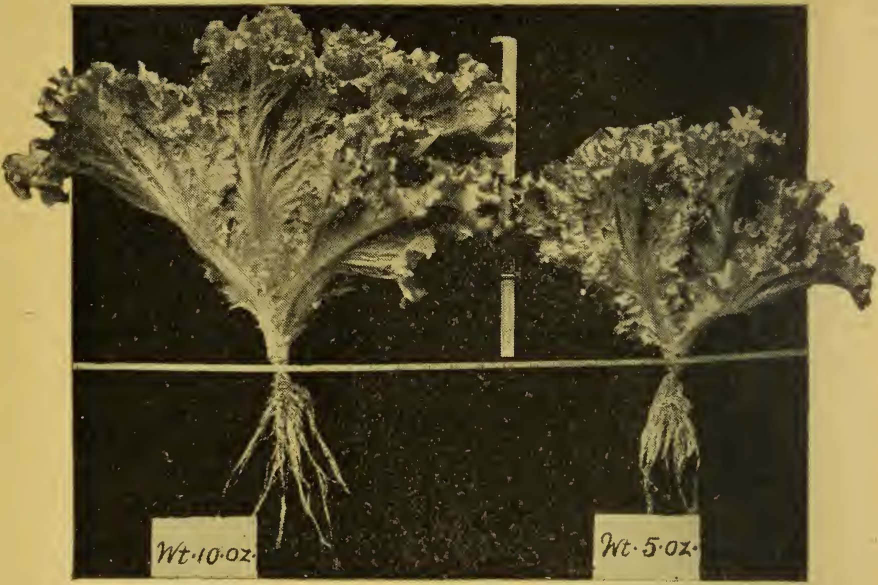

FIG. IV.—SUB- AND SURFACE IRRIGATED PLANTS OF THE SAME AGE.

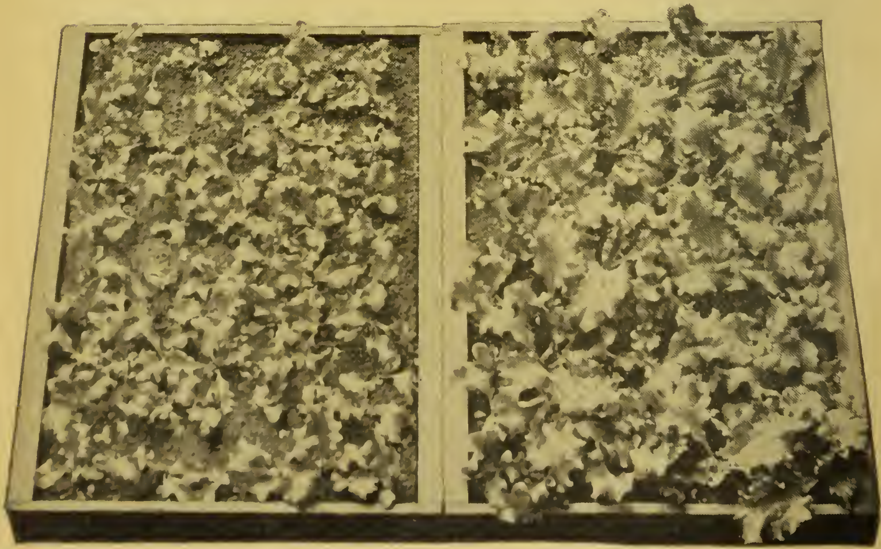

FIG. V.—SURFACE AND SUB-IRRIGATED LETTUCE PLANTS, GROWING IN FLATS.

than by sub-irrigation. It is an established fact that good head lettuce cannot be grown on heavy soil by surface watering, and the same is, in a measure, true of all varieties. It is evident, therefore, that sub-irrigation greatly enlarges the possibilities of lettuce culture under glass. It not only makes the work easier for new beginners but it makes it possible to use soil that would otherwise be precluded. More than that, it solves the problem of meeting competition from the South, which competition bids fair to ruin the business of vegetable forcing at the North, unless improved methods are adopted by Northern gardeners.

V. SUGGESTIONS REGARDING THE CULTURE OF LETTUCE UNDER GLASS.

This ground has been partially covered in a previous bulletin, but the interest in lettuce culture is growing, and inquiries are quite frequent concerning methods and appliances.

In the first place, local conditions should not be overlooked, such as soil and the market requirements. If the market demands head lettuce, then it is of the utmost importance that the soil should have a considerable per cent. of sand, and at the same time be sufficiently fertile and have capacity for holding moisture. Non-heading sorts, like the Grand Rapids, are not so particular as to soil, but it is a difficult matter to grow any kind on a soil with much clay in it, by surface watering, and even if sub-irrigation is practiced such soil should be avoided. It would be futile to attempt to grow lettuce according to methods in vogue in the East on a heavy clay soil. Swamp muck, composted with one-fourth or one-half horse manure, answers very well for either surface or sub-irrigation, particularly for the latter. It has the advantage of being light and easily handled, and never hardens; moreover, it has considerable capacity for water.

The addition of fine sand will greatly improve a clay soil, and it is advisable, if such soil is used, to take it from an old fence row, using the sod only. It may be inferred from the above that lettuce may be successfully grown on almost any soil, and such is the fact, if conditions are thoroughly studied and the details carefully looked after. Nevertheless it is better to select a soil naturally adapted to the purpose if possible, but in any case such artificial means as composting and sub-irrigation ought not to be neglected.

Regarding varieties but little need be said, as but very few are suitable for the purpose. Of those that form heads a good strain of the Tennis Ball is the best, but in this section it is not best to grow any of this class. Head lettuce is more particular as to soil, more subject to rot, requires more room and is longer in coming to maturity than Grand

Rapids or kindred sorts. In Eastern markets none but head lettuce will sell, but happily for gardeners in this and surrounding sections no such whimsical discrimination is made. Occasionally there is inquiry for head lettuce, but the Grand Rapids is usually taken as a substitute without complaint, and such being the case there is no need of growing any other kind. There is no other variety that will compare with it for profit in the region west of the Alleghenies, hence it is not necessary to offer any further argument to convince gardeners, within these limits, that it is the kind to grow.

Lettuce may be grown at any time of the year, but it flourishes best after midwinter until spring, and the demand is usually best at this time. But it is advisable to occupy the houses as early and as long as possible, hence the first sowings should be made in August or September. In large establishments it is customary to sow the seed in the beds that are used for the regular crop, and to transplant the young plants into the same beds, but in most cases it is better to sow in flats and to transplant into flats the first time also. The flats in use here are 16 x 24 inches, and two inches deep. These flats have slatted bottoms, and when placed in a shallow vat of water the soil in them quickly becomes saturated.

The labor of giving a single watering in this manner is more than is required to sprinkle the surface, but the watering does not need to be repeated so soon. The total labor required is about the same by the two methods, but watering by soaking, or by sub-irrigation, gives better results than sprinkling, hence it is recommended wherever practicable. It is by no means so impracticable on a large scale as may seem, for with vats, or water benches, conveniently located, the watering is easily done, and so thoroughly as to preclude any possibility of the plants suffering for water for several days.

Fig. V shows two flats, with lettuce plants 2 x 2 inches apart, those in the flat on the left having been watered in the usual manner, and those on the right by the method described. The actual difference is greater than appears in the picture, as the relative height is not shown, simply the leaf development horizontally. It is not unusual to increase the size in this manner 50 per cent. or more in the three or four weeks which the plants occupy the flats from the time of the first transplanting to the second, or when they are set in the beds.

In case flats are not used the plants may be set in beds and sub-irrigated in the usual manner, and thinned at the proper time, or all transplanted, as desired; but in any case it is advisable to sub-irrigate them during the entire period of their existence.

It is not advisable, in any case, to sow the seed where the plants are to stand until mature, as too much space is wasted in this manner before the plants are large enough to occupy it all. The proper plan is to keep the plants crowded as closely as they will bear, so as to occupy the space fully. There is a limit to profitable crowding, however, and 2 x 2 at the first and 6 x 7 inches at the second transplanting may be set as the lowest limit for the Grand Rapids. Head lettuce should be planted 4 x 4 inches apart at first, and 8 x 8 at the final transplanting, when set in beds or benches.

The plants should be kept growing from the start, and should receive no check for want of water. They may be forced as rapidly as possible by means of fertilizers and frequent stirring of the soil, but not by too high a temperature—50 to 60 degrees in the day time, and about 10 degrees lower at night, is about right. If the houses are kept much warmer than this, particularly at night, the lettuce rot is almost sure to injure or destroy the plants. If the foliage is kept wet by frequent sprinkling the rot is more likely to prevail than if no water is applied to the leaves, but it will occur in any event, if the house is kept too warm.

The depth of the soil in the beds, and the position of the beds, whether on the ground or on benches, is a matter of considerable importance, if surface watering is practiced, but less so with sub-irrigation. Near Boston, where head lettuce is grown extensively, the beds are on the ground altogether, and the soil is a foot or more in depth. There is a saving of the cost of benches by this method, and the soil retains moisture better than a smaller quantity would on a bench. For this reason it is better to have the beds on the ground where surface watering is practiced, but for sub irrigation it does not matter in the least where the beds are, and six inches of soil is as good as more. As a matter of economy it is better to place the beds on the ground, except where the space under the benches can be profitably utilized, as in growing mushrooms, pie plant, etc.

In lettuce houses it is not so important to have the plants near the glass as with some other crops, but in any case it is well not to place the roof any higher than need be, and to avoid shading the plants by the walls of the house. Ventilation is a matter that needs special attention in lettuce growing, for the same reason that overheating must be avoided. During very cold weather in winter is a critical time with the lettuce crop, especially if the days are dark and cloudy, for the reason that ventilation is apt to be neglected. The still, damp air gives the fungus, which causes the lettuce rot, a good chance to grow, and owing to the necessity of constant firing, the temperature is more likely to be too high than too low, hence a bad attack of the rot often occurs at such times.

It is safer, in such cases, to run the risk of reducing the temperature too much by frequent ventilation than to take the chances of the rot getting a start. Both extremes are to be avoided, but especially the one which favors the development of the rot.

Watering by sub-irrigation may need some explanation, but the method is so simple that a very short experience will enable any one to understand how to operate it. As in surface watering, the needs of the plants are to be studied, and water is to be supplied when they require it, as shown by the appearance of the foliage. Plants are not to be allowed to wilt, however, before watering, but the practiced eye soon discovers when they are in need of water. Sub-irrigated soil is often deceiving to the eye, as the top is dryer than the bottom, but a little experience will soon enable any one to determine, by running the hand into the soil, when water is needed. It is generally safe to keep the surface of the soil quite dry, while the lower portions may be so wet that when pressed in the hand it will not fall apart, but will retain the shape given it by the hand when the pressure is removed. More water than this may be applied to lettuce plants, without injury, even to the extent of making the surface of the soil appear to be wet. By this method of watering there is less danger of over than underwatering, hence it is well to give water in abundance. This is especially true of lettuce, as it requires large quantities of water.

There is no need of sprinkling the foliage of lettuce plants frequently during growth. It may be well to sprinkle the plants once as soon as they are set in the beds, but it is not really essential, although they probably start to grow more quickly and surely than if sub-irrigated altogether. A slight wetting of the surface of the soil saves such a complete saturation as may be necessary otherwise, while the plants are small, and before the roots have penetrated to any considerable distance. To continue to water on the surface is not advisable, as it is not only a waste of time but compacts the soil, which involves extra labor in working it up again Contrary to the general belief, the plants are not benefited by having the foliage sprinkled, nor is it necessary to sprinkle the walks in order to introduce moisture into the air. These remarks refer to lettuce plants only, but so far as known might be applied to other vegetable crops.

As before stated, it is not known whether watering sparingly and frequently, or profusely and at long intervals, is the better plan; it appears to matter little which plan is followed, hence no rules can be laid down. It is possible to give sufficient water at the beginning to carry a crop of lettuce through, but we have not followed this practice, nor does it seem to be advisable to do so, for the quantity of water required varies with the season and the size of the plants. The best plan is to give water as the plants seem to need it, and to be sure to give enough, as with lettuce the danger lies in withholding rather than in overwatering.

When lettuce is to be grown late in the spring, a hot-bed, or a cold frame simply, answers better than a greenhouse, as the latter becomes too warm, while the beds are more easily ventilated. Moreover, a better use can be made of the greenhouse in growing tomatoes at this season of the year. It is not advisable, at any rate, to attempt to force lettuce in the greenhouse, in this latitude, later than the first of April. A bulletin on tomato culture under glass will be issued soon.

SUMMARY.

(1.) A water-tight bench bottom is necessary in sub-irrigation, and may be made of matched lumber, or of any rough lumber, the cracks being battened with lath, after which cement is spread over the bottom to the depth of half an inch. A better plan is to make the bench bottom of tile, with iron supports. A bed may be made on the ground also.

(2.) The irrigating tile may be laid lengthwise or crosswise the beds and the latter plan has been the more satisfactory. If long runs of tile are used there should be a slight fall of one or two inches to the hundred feet, and strips of tin should be inserted into the joints at intervals to check the too rapid flow of water to the lower end.

(3.) Sub-irrigation in the greenhouse grew out of an attempt to prevent lettuce rot, by watering below so as to avoid wetting the foliage.

(4.) Watering by sub-irrigation is more efficiently and cheaply done than by the ordinary method; sub-irrigated soil does not harden, but retains its original loose, friable condition, nor does it become mossy and water logged. Furthermore, plants are less liable to suffer from overwatering and disease by sub than by surface watering, and in consequence grow more vigorously.

(5.) These good effects are supposed to be largely due to the facts that sub-irrigated soil is always in a condition to allow the air to permeate it freely and that uniformity and constancy of the supply of moisture to the roots are assured by this method of watering.

(6.) The gain in weight of sub-irrigated lettuce over surface watered has been, in some cases, as high as 100 per cent., but in most of the experiments about 40 per cent. In one case the increase in the value of the crop was sufficient to pay the cost of the new bench bottoms, and in all cases the cost of reconstruction has been reimbursed the first season.

(7.) It is a fact that good head lettuce cannot be grown on heavy soil by surface watering, and the same is, in a measure, true of all varieties; but with sub-irrigation this kind of soil is not precluded, hence the method of watering greatly enlarges the possibilities of lettuce culture.

(8.) Local conditions should not be overlooked, such as soil and market requirements. It would be futile to attempt to follow Eastern methods in this section, because the conditions are different.

(9.) The head lettuces are grown in the East, but are not demanded in our markets, hence the Grand Rapids is more suitable here, as it can be grown more cheaply.

(10.) The practice in vogue in the East of making beds on the ground and of using a foot or more of soil, although the best plan there, is not necessarily so where sub-irrigation is practiced, as by this method six inches of soil is sufficient.

(11.) Lettuce flourishes best in the greenhouse from midwinter until spring, and is usually most in demand during that period, but late in spring it does better in beds out of doors, after which time the houses may be more profitably occupied with tomatoes.

(12.) The best plan of starting the small plants is in flats, and these are best watered by placing in shallow vats of water, so as to sub-irrigate.

(13.) The plants should be transplanted as soon as they show the second leaf, placing them 2 x 2 inches apart for Grand Rapids, and twice that distance for heading sorts; 6 x 7 inches for the former and 8 x 8 inches for the latter when planted in beds.

(14.) The plants should be kept growing from the start, but should not be forced in too high a temperature; 50 to 60 degrees by day and 40 to 50 by night being about right. A high temperature favors the development of lettuce rot.

(15.) Ventilation is important or rot will appear. The most critical time is in cloudy, cold weather, because it is then not easy to ventilate.

(16.) No rule can be given for watering, but when sub-irrigated the soil should appear to be rather dry on top, and wet enough below so that when pressed in the hand it will not fall apart when released, but retain the shape given it by the hand.

(17.) The plants may be sprinkled once when set in the bed, but after that it is not necessary and is a waste of time, nor is there any use of sprinkling the walks in order to introduce moisture into the air.

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 62. October, 1895.

THE GRAPE ROOT WORM, *Fidia viticida*, Walsh.

BY F. M. WEBSTER.

PREVIOUS HISTORY.

The first published notice of this insect that I can find in our literature extends back only to 1866, when the species was as yet undescribed, and during the summer of which year the late Mr. B. D. Walsh, afterwards State Entomologist of Illinois, received the adult insect from Kentucky, where it seems to have been depredating on the foliage of the grape in great numbers. Mr. Walsh stated in his reply that, although he had taken it in small numbers on the native grape in both northern and southern Illinois, this was the first report of their appearance in destructive numbers. The habits of dropping to the ground and feigning death when disturbed, and of feeding on the upper surface of the leaves were recorded, and the middle of June stated to be the date of its annual appearance in Kentucky. Of the larval stage, Mr. Walsh wrote, tentatively, as follows:

> "Most probably, as with the Flea-beetle of the Grape-vine, it is in the larva state that it does the principal part of the damage, and as the larvæ of all beetles are altogether unlike the perfect insect, you may not have recognized their identity. The larva of this species will be an elongate grub, with a hard shelly head, a soft body, no wings of course, six legs in front and a single "pro-leg" or short fleshy stump which it uses as a leg at its tail; and the color will probably be some obscure shade of pale drab or brown. It will be found sluggishly feeding on the surface of the leaves along with the perfect insect, and as soon as ever they first appear in the spring you should use every exertion to destroy them. A single female larva destroyed at that time may prevent the generation of a hundred thousand in the course of the summer; for I have little doubt this species is many-brooded, *i. e.*, that there are several generations of them in one year."[1]

Later, in the same publication[2], Mr. Walsh describes and figures the insect, giving it the name it now bears, and indicated the points of difference between it and *F. longipes* Melsh. He adds that this beetle had long been well known to himself and other entomologists, but, except to note the occurrence of a single specimen on a Catawba vine in his garden, and to suggest that it might in future swarm in other localities besides Kentucky, he gives nothing additional. A few months later, in August, or September, 1867, the same gentleman acknowledges receipt of the same insect from the vicinity of St. Louis and Bluffton, Missouri, where they were eating both leaves and fruit of the grape. Among the material sent was a single specimen of *F. longipes* Melsh.[3]

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[1] Pract. Ent., Vol. I, pp. 99–100, 1866.

[2] Loc. cit., Vol. II, pp. 87–88.

In his first Report on Insects of Missouri, Prof. Riley makes the following statements:

> "One of the worst foes to the grape-vine that we have in Missouri is the Grape-vine Fidia. It is of a chestnut brown color, and is densely covered with short and dense whitish hairs which give it a hoary appearance. I have found it very thick in most of the vineyards which I visited, and it is almost universally miscalled the "Rose bug," which is, however, a very different insect. It is found in the woods on the wild grape-vine and also on the leaves of the *Cercis canadensis;* but of the tame vines it seems to prefer the Norton's Virginia and Concord. It makes its appearance during the month of June, and by the end of July has generally disappeared, from which fact we may infer that there is but one brood each year. The manner in which it injures the vine is by cutting straight elongated holes of about one-eighth inch in diameter in the leaves, and when numerous it so riddles the leaves as to reduce them to mere shreds. The preparatory stages of this beetle are not yet known."[4]

In 1870, Mr. Riley received the beetle from Bunker Hill, Illinois, where it was feeding on the leaves of grapes.[5]

In his "Materials for the Study of the Phytophaga of the United States," Mr. G. R. Crotch describes the species *murina* from the Middle and Southern States, but seems to have overlooked *viticida* and did not mention it.[6] In his paper on "The Eumolpina of Boreal America," Dr. G. H. Horn unites *murina* with *viticida*, and gives the distribution as being from the "Middle States to Dakota, Florida and Texas."[7] He also unites with the species *F. lurida* Leferre, "Catalogus Eumolpidarum," Mem. Liege, 1885, p. 76, (separate).

Prof. H. F. Wickham records *viticida* from the vicinity of Iowa City, Iowa,[8] and Prof. Riley has recorded both *murina* and *longipes* as injuring the foliage of grapes at Vineland, Arkansas.[9]

This is a summary of all the available information relating to the species, in December, 1893, the time when I began my studies, of larvæ sent me from the vicinity of Cleveland, Ohio, where they were said to occur in great numbers about the roots of grapes, causing very serious injury by eating the outer bark.

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[3] Loc. cit., p. 118.

[4] First Rep. Inj. Ben. Ins. Mo., p. 182, 1869.

[5] Am. Ent. and Bot. Vol. II, p. 307, 1870.

[6] Proc. Acad. Sci. Phila., 1873, p. 53.

[7] Trans. Am. Ent. Soc., Vol. XIX, p. 193, 1892.

[8] Bull. Lab. Nat. Hist. Univ., Iowa, Vol. I, p. 81, 1888.

[9] Insect Life, Vol. V., p. 18.

DESCRIPTION OF THE SEVERAL STAGES.

Of the following descriptions, that of the adult is copied from Walsh, those of the preparatory stages are my own, drawn from material taken from the vineyards about Euclid and Nottingham, Ohio:

ADULT: A, Fig. 1. (See accompanying plate.) Chestnut rufous, punctured and densely covered with short grayish-white prostrate hairs, so as to appear hoary. Head rather closely punctured, with a fine longitudinal stria on the vertex. Clypeus and mandibles glabrous and black, the clypeus with a subterminal transverse row of punctures, armed with long golden hairs, the mandibles minutely punctured on their basal half. Palpi and antennæ honey-yellow verging on rufous, the antennæ three-fourths as long as the body, with joint four fully one-half longer than joint three. Thorax finely and confluently punctured, about as long as wide, rather wider behind than before, the sides in a convex circular arc of not quite sixty degrees, the males with the thorax rather longer and laterally less strongly curved than the females. Elytra punctato-striate, the stria subobsolete, the punctures approximate, and rather large but not deep, the interstices flat and with close-set fine shallow punctures. Legs with the anterior tibiæ of the male suddenly crooked three-fourths of the way to their tip; anterior tibiæ of the female as straight as the others. Length of male .24—.27 inch; female .24—.28 inch.

LARVA: C, Fig. 1, Pl. 1. Length, 8. to 10. mm. Color, body white, head and cervical shield honey-yellow, clouded with white, mandibles and clypeus darker with the tips of the former and the prominent clypeal suture nearly black; spiracles and claws brownish-yellow, the former and anterior pair of feet sometimes darker. Head considerably smaller than first thoracic segment which is a little smaller than the second, third equal, from which the body tapers slightly and regularly to twelfth, thirteenth smaller, orbicular and almost rudimentary, containing the vent, the latter forming depressions in the form of the letter Y and dividing the area into three elevated spaces on each of which are situated a number of short, decumbent spines, pointing inward, and on the spaces between the two branches of the Y are two larger spines, both of which are erect; there are also groups of shorter spines on the twelfth segment, and with two longer spines, likewise occupy elevated areas; on the ventral surface of all the segments, except the thirteenth and thoracic, are many short, reddish, ambulatory setæ; above, there is a single transverse row of short bristles emanating from small pustules, which are more conspicuous posteriorly. The first spiracle is located between the second and third segments, and is frequently a little more distinct than the others which are located on each segment, from fourth to eleventh, inclusive. On the head, *a*, Fig. 1, Pl. 1, the clypeal suture is prominent, roughened and broadly obtusely bifid immediately above the base of the mandible, the outer tooth being the smaller, and between it and the larger arises a stout bristle, while others are placed distantly along the crest of the ridge. Mandible, *b*, Fig. 1, Pl. 1, with a broad obtuse tooth on the inner edge toward the tip. The labrum is provided with a stout bristle about midway between the center and the lateral margin, with a closely placed row around the frontal edge, these last being usually broken off in full grown specimens. The somewhat pecular antenna, *c*, Fig. 1, Pl. 1, is four jointed, the basal being shorter and slightly more robust than the second, from which it is rather indistinctly separated, the third is still smaller, the fourth being of two parts, the outer cylindrical and surmounted by three bristles, while the inner is nearly the form of a right angled triangle, with the perpendicular inner most, the hypotenuse facing the cylindrical portion and having a somewhat scoop shaped appearance. Labium thick and trilobed, the outer lodes covered on the upper surfaces with minute, spinular scales; palpi, *f*, Fig. 1, Pl. 1, rather slender, cylindrical, slightly curved and terminating with a single bristle. Maxillæ, *e*, Fig. 1, Pl. 1, well developed with the inner lobe armed with stout spines, the outer lobe prominent and four jointed.

PUPA: B, Fig. 1, Pl. 1. Length, 6 to 8. mm. Color, white with pinkish tinge about head, thorax and posterior extremity; head with a semicircular row of four spines, the frontal pair erect, the other two smaller and divergent; near anterior margin of thorax there is a similar row, likewise placed in the form of a semicircle, while just behind these is a cluster of four smaller and more erect bristles placed in pairs, the anterior of these being the most widely separated. Anterior femora armed at tip with a short, hooked spine, while above and at one side is a single, straight spine terminating in a bristle, posterior femora armed with a stouter hook and two stouter erect spinular bristles, middle femora unarmed; at posterior extremity are two stout, flattened hooks, whose points extend upward; on the dorsum of the penultimate segment is a row of four distantly placed decumbent spines while on the preceding segment is a median, transverse, closely placed row of four, stout, erect spines, each of the other segments being provided with a single row of minute, short bristles, with two larger ones on the scutellum.

In the majority of my specimens the anal hooks are as described and shown in the figure. In some, however, they are bifid, one hook extending upward and the other downward, in which case the spines are much stouter, while beneath are two very short, stubby, hooked appendages. In one specimen one of the anal hooks is bifid and the other simple, and beneath the former is one of the short appendages while there are two of these, closely placed beneath the latter.

EGG: The egg is 1.15 mm. long, with the greatest diameter considerably less than one-third the length; form elongated with the ends equal and obtusely conoid. The shell is very flexible, and when, as is often the case, they are crowded into a small space the form is often greatly distorted. When first deposited they are of a white color but soon take on a yellowish cast. The egg period is eight days, though granulation is not clearly visible until the third day; on the fourth there appears near each end a narrow semi-transparent band, while the granulation is much coarser; on the fifth the blastodermic disc is clearly defined, the bands becoming wider; on the sixth, one of the bands has nearly disappeared and the other has more than doubled in width, segmentation having clearly begun; on the seventh, one band has entirely disappeared and the semi-transparent space along one side, which is first observed on the fifth day, is now much wider and extends from the semi-transparent band nearly to the opposite end of the egg, with granulation of blastodermic disc very coarse and segmentation progressing very rapidly; on the eighth, segmentation more clear and quickening was first observed; on the ninth, the young larva appears, being but very slightly larger than the egg, from which it gains exit by backing out, the brownish tips of the mandibles being clearly visible through the shell.

HABITS OF THE ADULT.

In northern Ohio the larvæ pupate, largely at least, in June, though I found pupæ in limited numbers on the 8th of August, which transformed to adults two days later, and adults are abroad in very limited numbers the first week in September. It is probable that these were delayed individuals, the result of larvæ which did not fully mature the previous autumn. On pupating, the larval skin is pushed off posteriorly and may be found in a compact disc in the earthen cells, after the adults have emerged. A very few pupæ may be observed as early as the first week in June, and by the 23d fully ninety per cent. of the larvæ have passed into this stage, the period of which is not far from a fortnight. At this date, the adults begin to appear, and pairing at once commences, both sexes now feeding on the lower leaves, though, later in the season, they are found higher up on the youngest and most tender foliage. The feeding is done entirely on the upper surface of the leaves, except where the fruit is the object of attack, and is done by gathering a quantity of the substance of the leaf in the mandibles and jerking the head upwards, after which the body is moved a step forward and another mouthful of food secured as before. After securing a few mouthfuls in this way they move to another place and begin again, thus eating out numerous, chain-like areas of irregular length, as shown in Fig. 3, Plate 1. On varieties of the grape having a velvety under-surface to the leaves they eat only to the lower epidermis, on others entirely through the leaf. When alarmed they usually draw up the legs and fall to the ground, where they are not easily distinguishable from the soil; if, however, they do not drop at first alarm, or during a high wind, they will probably pay no attention to almost any amount of disturbance, and can be readily caught with the fingers. In the insectary, adults lived upwards of two months, though in the vineyards they have mostly disappeared by August 1st.

It would seem that an insect whose larvæ fed upon the roots of their mutual food plant would place its eggs in a position most convenient for the young to reach their sustenance, but in this, almost the contrary seems to be the case, as the eggs are deposited in or under the bark of the previous year's or even an older growth, and often several feet above and beyond the roots, and the young larvæ, whose feet are not fitted for walking on vertical or steeply inclined surfaces, tumble to the ground and find their way to the roots as best they can. This mode of oviposition, however, finds a parallel in a closely allied species, *Adoxus obscurus* Linn, whose larvæ, in Europe, also feed on the roots of the grape, and the eggs, according to the studies of Mr. E. Dupont, are deposited on the leaves.[10] Although *A. obscurus* is a grape affecting insect in Europe, in America the species itself, which occurs in Colorado, Nevada and California, has but once been reported as injuring grapes, and in this case the foliage only and under the name of *vitis*, a variety that occurs from New Hampshire to Lake Superior, Utah, Colorado and Washington, but over this area has never been recorded as attacking the grape. The outbreak in question occurred at Stockton, California, in May, 1890. In the only published record[11] we have of this attack, both the beetle and an injured leaf are figured, showing a similarity of attack as compared with *F. viticida*, though the figure of the beetle is too poor to render its recognition possible.

With the species directly under consideration, the eggs are, as a rule, placed under the slightly loosened bark, as shown in Fig. 4, Plate 1, several dozen being frequently found in a single cluster, the ends pointing obliquely toward a common center. The number of eggs deposited by each female is as yet undetermined, but as giving an idea of the number placed on a single vine, over 700 have been taken from one vine, while from a section sixteen inches in length and one inch in diameter, from the main trunk of another, I took 225 eggs. Though I have once or twice found eggs pushed down between the earth and the base of the vine, there seems to be no partiality shown for this or any other locality

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[10] Progres Agricole et Viticole, Vol X, pp. 576–578, Sept., 1889.

[11] California State Board of Horticulture. Division of Entomology. Destructive Insects, their Natural Enemies, Remedies and Recommendations. By Alexander Craw, Quarantine Officer and Entomologist. Sacramento, 1891.

on the vine, the sole object being to secure a place wherein to secrete them. However anomalous this method of oviposition may appear to us, we must not lose sight of the fact that the natural habit of the wild grape differs somewhat from those of the vineyard, and the habit of oviposition has been followed by the female long enough in the past to thoroughly adapt the anatomical structure of the ovipositor for its requirements. The ovipositor consists of a retractable, telescopical arrangement, having a somewhat loose and baggy appearance, but terminating with a slender, flattened, more chitinous and rigid appendage, from 1.3 mm to 1.8 mm in length, the tip of which is provided with a pair of short, obliquely truncated forceps, black in color except at the ends, which are white and provided with a number of short, stiff hairs. At the base of these is a couple of slight lips, which are rounded in front, apparently forming a socket for the reception of the end of the egg. See Fig. 2, *a*, *b*, *c*, Plate 1. From what I have observed respecting the oviposition of other insects, it would seem that one end of the egg was held in the forceps, and, while prevented from slipping backward by the lips, as described, was deftly pushed under the bark and left there. This last segment of the ovipositor appears too slender to admit of the egg passing down internally to the forceps, though such may be the case, and I am puzzled to know how else the former can be secured by the latter. It really looks as though the oviduct might end in a loose sack, accessible in some way to the retracted forceps which, grasping the egg, carries it outward to its place of deposit. The eggs, though they adhere quite tenaciously to each other, are less strongly attached to the vine or bark, and I have found them lying on the surface of the ground under the vines, having doubtless been loosened and detached by the swaying of the vine in the winds.

HABITS OF THE LARVA.

Some of the habits of the larva have been indicated in the foregoing. When the young larva drops to the ground it runs about quite actively, but I have never observed them attempting to dig downward. If they find a crack or crevice they enter it, and probably some of them reach the roots in this way, but I think it more probable that the larger number go downward at the base of the vine. Still, as the little fellows will live for a week or more without food, it is not strange that many of them should find their way to one of the many fresh succulent fibrous roots that are found near the surface of the ground, though I have seen them die on dropping on the hot sand. However, the fact that a large majority of the worms are found near or directly beneath the point where the large roots leave the trunk, is indicative of the point of entrance of the larger number of the very young worms. It would appear that the very young larva, after it has fed for a short time on the small fibrous roots, turns its attention to the larger and tougher portions, eating off the bark, as shown in Figs. 5, 6, Plate 1, and following the smaller ones outward. Where the larvæ are numerous—and as many as sixty-eight have been taken from about a single vine—the injured roots simply rest on a bed of the castings of the worms. In spring, larvæ have been found fully three feet from the trunk and nearly a foot below the surface. The larva appears to develop very rapidly, many having reached their full growth by the middle of August. When full fed they work their way to one side and form earthen cells, within which they remain without food until the time of pupation the following June, curled up in such a manner as to bring the head in close proximity to the ventral surface of the posterior segment. In April I have found an occasional larva less than half grown, and though these were in cells when found, it is probable that they return again to the roots and finish their growth, transforming to adults even as late as the middle of August, an occasional adult being observed abroad as late as September.

NATURAL ENEMIES.

As is usual in cases of a superabundance of the individuals of a species, these were quite abundant in the vicinity of Cleveland, Ohio, where *Fidia viticida* developed in great numbers during the past summer. While the adults are doubtless destroyed by birds to some extent, no such cases were noticed, nor were insectiverous birds present in unusual numbers. The same may be said of predaceous insects, no enemies of the larvæ having been observed in situations leading one to suspect them of destroying either the larvæ or pupæ. With the eggs, however, the case was quite different. The little brown ant, *Lasius brunneus*, var. *alienus*, was observed several times in the act of feeding upon them though they could only reach such as were much exposed. A small mite, possibly *Tyroglyphus phylloxeræ* P & R, though Dr. Geo. Marx, of Washington, D. C., was not able to refer the immature specimens sent him to the proper genus, was frequently observed to approach a cluster of eggs and extract the contents of several in succession, while still another smaller mite resembling *Hoplophora arctata* Riley, was several times found similarly engaged. The remaining two species are described in the following pages, by Mr. Ashmead.

The fact of *Fidiobia flavis* Ashmead, being a parasite on coleopterous ova having been privately called in question by both Mr. Ashmead and U. S. Entomologist, Mr. L. O. Howard, owing to its belonging to a group supposed to be parasitic on Diptera, exclusively, I give full details of the rearing of the specimens from which the original description was drawn.

The cluster of eggs was given me by Professor Hobbs, of the Western Reserve Medical College, who found them on a vine, located practically as shown in Fig. 4, Plate 1, and removed them therefrom in a body they remaining attached to each other, and placed them in a watch glass in his laboratory. On looking at them some days later the pupæ could be distinguished within the shell, both the eyes and ocelli showing very clearly. This was on July 20, and during the following four days I watched them carefully, at the end of which time I distinctly saw one move about within the shell of the egg, and later make its way forth. Another individual was removed from the shell, it having perished prior to hatching. No one saw these eggs deposited by the parent beetle, but there was no difference either in form or color from those which Fidia larva emerged, and the only possible way that an error could be accounted for would be to suppose that a minute fly, whose eggs exactly counterfeited those of Fidia, had oviposited among the eggs of the latter, and the Fidioba had detected them and placed her own ova in them. This appears to me to be an improbability, to say the least. With *Brachysticha fidiæ* Ashmead, though I did not witness the deposition of the eggs by the beetle, I did observe the parasite oviposit in them, on August 4. On the 14th the pupa was well defined within the shells, and on the 18th this stage had advanced so that the eyes were clearly visible, being about as were the Fidiobia when I first saw them. The adults emerged on the 21st day after eggs were deposited.

REMEDIES AND PREVENTIVES.

The foregoing gives as correct an account of the life history of this insect as could be obtained in a single year's observation, for it must be remembered that, up to the time that these studies were begun, absolutely nothing was known of its development, or the food habits of the larva. So then, it became necessary to first learn the habits of the pest in all of its stages of development in order to be able to determine where and at what time it would prove to be the most susceptible to remedial measures; information that could only be secured as fast as nature chose to unfold her mysteries to us, besides, by the time this information had been secured it was often too late to take advantage of it. It was a case where absolutely nothing could be anticipated in advance of the coming. When the larvæ were first shown me in December, I could only say that they belonged to some species of the great family of leaf eating insects, the *Chrysomelidæ*, and the appearance of the adult in the vineyards was only anticipated by placing a number of the larvæ in the insectary where their development was hastened, and I secured the fully developed insect in this way some weeks in advance of its coming under natural conditions. Having the adults, obtained in this manner, gave no hint as to the date of their appearance under a natural environment, nor in the least solved the mystery of place of oviposition, or even the period of time over which this labor extended, or in fact whether the insect was single or double brooded. In fact, not until the ground had frozen in December following did I feel at all sure that the entire cycle of the species had been observed, and that we had a clear record of its development throughout the year.

My first adult appeared in the insectary March 29, followed shortly after by several others, a part of which were placed on an isolated part of the vine, from the roots of which they had been reared, and the leaves sprinkled with a solution of one ounce of Paris green to sixteen gallons of water. These adults lived here from three days to a week before succumbing to the effects of the poison, one pair, after remaining on the vine for twenty-four hours, were removed and continued to live for a couple of weeks, as did also those left on the unpoisoned portion of the vine, which indicated that the arsenites would have a very slow effect when applied of the strength ordinarily used for insecticides. On April 13, I applied kerosene emulsion, salt and also bisulphide of carbon to the roots of vines known to have been attacked by the larvæ, and later sent to the owner of the vineyard, Mr. J. W. Maxwell, a quantity of kainit which was placed about the roots of other infested vines. Three weeks later I examined the vines thus treated but found no larvæ had been killed about any except such as had been treated with kerosene emulsion, where only such as had actually been reached by the application were jured, while about those where the bisulphide of carbon had been used not a single living larva was found. About one of these vines six ounces and about the other four ounces of the bisulphide of carbon had been used. One of these vines was dug out at the time of examination but the other put out a few leaves later on but finally died also, though whether from the attacks of the worms or the effect of the insecticide it was impossible to prove at the time, but the probability was in favor of the former effect being the cause of the death of the vine. This experiment, though carried on a limited scale, indicated plainly that the destruction of the larvæ about the roots of the vines would prove no easy task, and if the bisulphide of carbon was used the expense would be very considerable for the material alone, to say nothing of the cost of applying.

There seemed at this stage of the investigation to be a better prospect of destroying the eggs or young than either adults or full grown larvæ, and hence these were watched for with fond hopes that we might here find the weak point in the life of the species; at least it did not seem possible for the pest to be less amenable to remedial measures than it had been found to be up to this time.

My investigations were from this on carried on in the vineyards of Mr. J. W. Maxwell, of Euclid, Mr. W. W. Dille, of Nottingham, and the Slade Brothers, of East Cleveland, to all of whom I am greatly indebted for assistance. Indeed Messrs. Maxwell and Dille, from first to last gave both time and money to the working out of the problem within their respective vineyards, and the progress made in these studies and experiments is to a considerable extent due to their liberality.

With the appearing of the first adults, late in June, was begun a long series of experiments with the hope of destroying them before they had oviposited, or, failing in this, to destroy the eggs or the young before the latter could establish themselves upon the roots. It is unnecessary to go into the details of each and every experiment. The last week in June, nearly all of July and the greater portion of August was spent in experimentation with various substances for the destruction, first of the adults, next the eggs and finally the larvæ.

For destroying the adult insects, arsenical poisons were tried, varying in strength from four ounces to fifty gallons of water up to one pound of London purple with lime added to prevent injury to the foliage. The last was tried by Mr. Dille, and there appeared to have been great numbers of the beetles destroyed—just how many it was impossible to determine as it was plain that new individuals came to the rows of treated vines each day, and though there were many dead on the ground, many more were eaten by ants; while still others as they fell from the vines still retained enough life to crawl away into cracks and under clods, so that it was impossible to find them. There seemed every reason for believing that this amount of poison would be effective; but by the time we had learned this it was too late to use the poison in such amount with safety, and I think this will prove the greatest drawback against the use of any poisonous substances in fighting the pest in the adult stage. One experiment was tried with arsenate of lead, one pound to 150 gallons of water, but without effect. As it has since been found necessary to use double or treble this strength in order to destroy the Elm Leef-beetle, its use in the vineyard for Viticida is practically probibited, not only on account of the cost but also of the danger in applying such an amount so late in the season as will be necessary to destroy the pest before oviposition has been effected. Kerosene emulsion was tried of various strengths, both for spraying the vines and also as against the beetles after these had been jarred from the vines and were lying on the ground. It was found that spraying the vines did no good, but injured the appearance of the grapes, while when applied to the fallen insects, unless they were literally drenched, a large proportion would recover. Pyrethrum in solution, one ounce to two gallons of water, killed many, but fully as many recovered from the effects of the application; though, as with the kerosene emulsion, it was tried as against the beetles on the vines and those that had fallen to the ground. By the time all my experiments had been carried out the season had advanced to late July, and the major portion of the eggs were known to have been deposited, so that I was obliged to very reluctantly give up this part of the fight and turn my attention to the eggs and young.

From the date of the appearance of the adult beetles in the insectary the place of oviposition had remained a profound mystery up to the 3d of July, when, while I was in another part of the State, Mr. Maxwell found them tucked under the bark of the vine as illustrated in Fig. 4, of the accompanying plate. Could we apply anything to destroy the eggs before these hatched, or could we prevent the larvæ getting into the ground after hatching in case we failed to destroy the eggs? By submitting eggs to kerosene emulsion it was found to be fatal to them, but when we applied it to the bark of the vines, even in the form of a strong minute stream, only a comparatively small number were reached, while many were so snugly tucked away under the bark as to be absolutely protected from harm so far as our efforts were concerned. Besides this, later in the season, when the grapes ripened, it was found that while the kerosene used in the emulsion did not affect the flavor of the fruit or leave any distinguishable odor yet the purple pubescens was so badly spotted as to render the grapes unsalable except for winemaking.

It now remained to be seen how the young larvæ would make their way to the roots after hatching from the eggs. If these crawled down the vine to the roots, as the greater number usually found near the base of the vine would indicate, then a band of tar or some other adhesive substance would prevent this and probably capture and hold many of them. Only another was added to the now long list of disappointments, when I lay on the ground and with a hand glass watched the minute worms leave the egg and after crawling about for a short time fall clumsily to the ground, not a single individual being observed to make its way down the vine. On reaching the ground there was no attempt made to burrow downward, and the roots appeared to be reached by the way of cracks and crevices in the earth, or directly down about the base of the vine, where, as a matter of fact, the larger number would naturally fall, though it is doubtful if more than one larvæ out of a hundred hatching from the eggs would succeed in reaching the roots at all. As there was no hope of intercepting the young larvæ between the place of hatching and the ground it was thought that air slacked lime, if scattered along under the vines, might destroy such young larvæ as fell upon it, and Mr. Maxwell and others drew several loads of lime and spread it along the rows; but later in the season I found plenty of them on the roots directly under where the lime had been applied. That the larvæ dropped from the vines to the ground in considerable numbers, and that in their progress downward they were driven from a direct course, was proven by laying down shallow wooden trays with the bottoms covered with tar, which caught and held them as they fell into it. The Slade Brothers claim, and I think not without good grounds, that if the soil is kept in a loose and well pulverized condition and banked up slightly toward the row, thus covering the roots more deeply with light soil that will not crack, many larvæ will be unable to reach the roots that would otherwise do so. I have observed the young perish soon after dropping on the hot sand beneath the vines, and it seems probable that with well pulverized soil drawn up about the base of the vines and covering the roots to an unnatural depth, during the period of egg hatching, or approximately during the month of July, the number of larvæ reaching the roots might be materially reduced, but it must not be supposed that this will constitute a full protection from attack.

From the foregoing it will be seen that, despite all our efforts, the larvæ had entered the ground in large numbers, and it seemed imperative that something be done to destroy them before they had done their work. Though the effect of bisulphide of carbon had been so flattering in the limited experiment carried out in the spring, I had left the further trial of that substance as a last resort, well knowing that with the low price of grapes the vineyardists would be very reluctant to make the necessary expenditure of time and money.

In the long series of experiments with bisulphide of carbon the grade known as "Fuma" was used, the material being purchased in bulk, direct from the manufacturer, Edward R. Taylor, of Cleveland, and the experiments numbered in all upwards of a hundred, Mr. Dille treating his whole vineyard and Mr. Maxwell several acres. It is useless to go into the details of all these experiments, though a careful record was kept of them all. The fluid was placed in holes made in the earth about the vines with an iron bar, and experiments were made with various amounts from one-half ounce up to three and four ounces per hole. Then the holes were placed at different distances from the vines and in different positions about them. As the larvæ were very small, they having to be searched for with a hand glass, and a whole day being required to examine the roots of three or four vines, it will be understood at once that the labor involved in these experiments was simply immense Among the earlier experiments we could only judge of the efficiency of an application by the number of minute living larvæ found about treated vines; but later on, when the larvæ were nearer full grown, no glass was required and both living and dead could be counted without trouble, though even in such cases the labor of examining the treated vines was very great.

Bisulphide of carbon, poured directly down the trunk of the vine, among the roots, was fatal in every respect, killing both larvæ and vine, and we soon learned that the fluid would kill the roots wherever it came in contact with them, but that the fumes would follow along their length for a considerable distance, destroying any larvæ that might be in the near vicinity, even though confined within their earthen cells. This rendered it necessary to so arrange the holes, into which the carbon was placed, as to prevent striking any of the larger roots and yet fumigate the soil about them. As the young vines are set in such a manner that the roots are almost entirely to one side of the vine, it was found that the best results could be secured by making the holes somewhat in this position, x indicating the position of the vine and the three .'s the position of holes: x :· That is, a hole was paced ten inches each side of a point one foot from the vine and directly over the roots, while the third was placed a foot beyond and in a direct line with the vine, the three thus forming a triangle with the vine one foot beyond the base. In this way it is possible to place two of the three charges quite near the vine, one on each side of the main roots, while the third falls directly over the smaller ones. Applied in this manner, four to six ounces to each vine, at a cost of about three cents per vine for the material, the best results were secured, but unfortunately, not in our largest and most expensive experiments. We had yet other disappointments to meet, none of which we could foresee in advance of their coming. Mr. Dille treated his whole vineyard in July and Mr. Maxwell, though not applying the bisulphide of carbon to his entire vineyard, yet treated several acres at much expense of time and money, both for material and perfecting machinery for its application. The weather during the time our experiments were being carried on was very dry, and we experienced the truth of what the French had evidently already learned, viz., that bisulphide of carbon cannot be used with success in ground saturated with water or in soil that is over dry. In early October both vineyards were carefully examined, and in Mr. Dille's, which was on lower land and of soil rather more compact, the effect had been more satisfactory than at Mr. Maxwell's, where the land was higher and therefore dryer, as well as more loose and friable. While from fifty to seventy-five per cent. of the worms had been destroyed at Mr. Dille's in no case had more than half and usually less been destroyed among Mr. Maxwell's vines. In both cases many larvæ were found whose diminutive size plainly showed that at the time of application they were

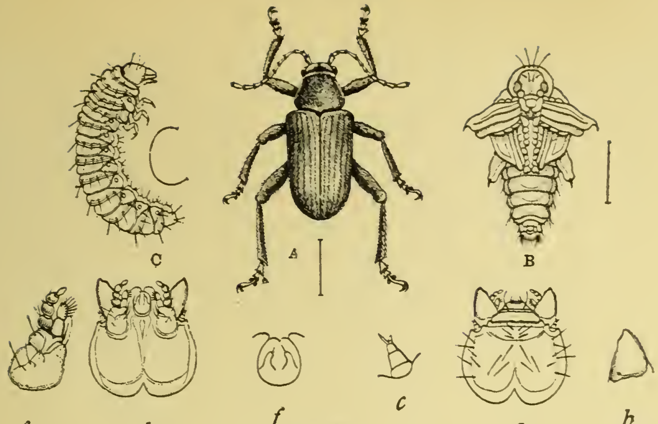

FIG. 1

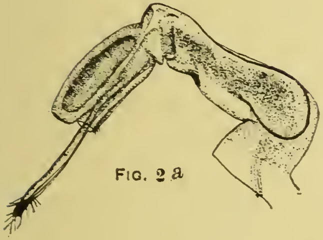

FIG. 2 a

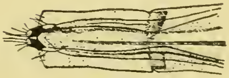

FIG. 2 c

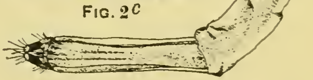

FIG. 2 b

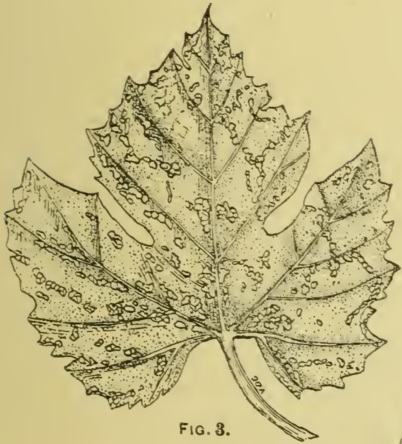

FIG. 3.

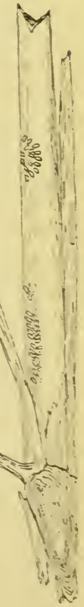

FIG. 4

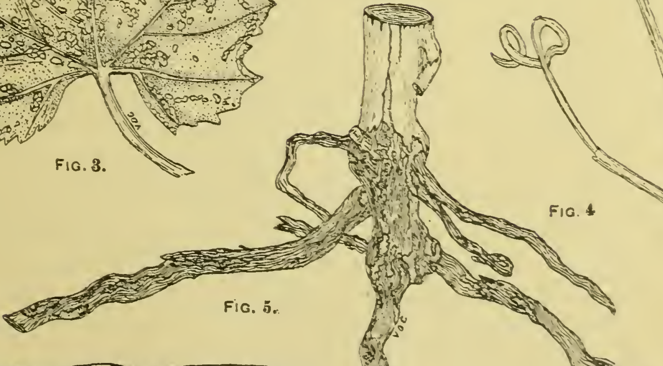

FIG. 5.

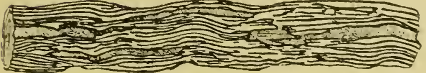

FIG. 6.

either unhatched or very young and had not penetrated the earth far enough to come in contact with the fumes of the bisulphide of carbon. This seemed to settle the point regarding the application of this remedy during July or even August, months that are usually lacking in rainfall, and before all of the worms have entered the ground.

December 15 Mr. Dille applied carbon bisulphide to several rows of vines, using about six ounces to each vine. Soon after the ground froze over for the winter, and no examination was made until the following April, when the results were found to be such as not to warrant so late an application, though a very large number of the larvæ had evidently been killed by the application, as all of the worms were then within reach, including the delayed individuals also. April 16 Mr. Dille made another application of the carbon bisulphide to several rows not including such as had been treated in December. Unfortunately, I was not able to examine the vines treated in this experiment until early in June, when a very few worms were found alive about the roots, though it was of course impossible to determine how many had been killed, and their bodies having decayed left no trace behind. An examination of both the Dille and the Maxwell vineyards, on July 31, showed that the beetles had not been nearly as abundant in the former as they were in the preceding year, and Mr. Maxwell stated that they were at any rate no more numerous in his vineyard, and that his vines appeared to be in a more thrifty condition. This increased vigor might have been due to the direct fertilizing effect of the bisulphide of carbon, as C. Oberlin, in Jour. Agr. Pract., 59 (1895), No. 13, pp. 459—464; 14, pp. 499—503; 15, pp. 535—540 calls attention to the fact that the yield of oats, alfalfa, crimson clover and beets has shown an increase when grown in soil in which bisulphide of carbon had been applied for the destruction of Phylloxera, in Alsace-Lorraine. Of course it is impossible to say how much of this check was due to our experiments and how much to the good work of natural enemies. Probably both had their effects, and the numbers of larvæ killed by our experiments would leave fewer adults to produce eggs for them to devour this season.

In summing up the results of our experiments with bisulphide of carbon as against the Grape Root-worm, it may be stated that it cannot be used to advantage earlier than November, on account of the prolonged season of oviposition, which prevents the later appearing larvæ from working downward to a sufficient depth to be reached by the fumes. It cannot be used to advantage in soil that is very dry or saturated with water, but must be used in soil that is damp. The most satisfactory results will probably follow its use in spring, in a damp soil, and applied in such a manner as to fumigate the roots without the fluid coming in contact with them, and when from four to six ounces per vine are used. It is not possible to kill every worm about each vine, and it is doubtful if it can be used profitably with the price of fruit as low as it has been during the last two years. It can in this case be used as a preventive, but not as a remedy.

As against this pest, then, I would recommend spraying with arsenical poisons, one pound Paris green or London purple with five or six pounds of lime to each one hundred gallons of water, sprayed thoroughly on the leaves at least as early as the 25th of June, and not later than the middle of July. The thorough and frequent cultivation, including the pulverizing of the soil and keeping as great a depth of this as possible over the roots and closely about the collar of the vine during July and August, so as to prevent the young from getting down to the fresh young roots that are thrown out at this season of the year. The mounding up of dry, finely pulverized soil about the base of the vines to be removed later on, might be of great service in preventing the young from entering the ground and reaching the roots. Whatever management will tend to cause the roots to grow deep in the soil, and prevent the growth of roots near the surface, will also tend to ward off attack, and on the same principle as the mounding. Bisulphide of carbon should be applied as indicated in the foregoing, and either in connection with this or any of the others I would recommend the free use of some fertilizer that will stimulate growth and thus overcome the effect of any slight attack on the roots from the worms. It will be noticed that all of the measures suggested as either remedial or preventive are not applicable in wet weather, and one, the bisulphide of carbon, is also worthless in extreme dry weather. To offset this, however, none of them in any way injure the parasites but have the effects of auxiliaries, a point which it seems to me is worthy of the most careful consideration, as their effect is a direct prevention. I am here led to suggest another measure, so far as I know not now in use outside of Massachusetts, where it is being used in fighting the larvæ of the Gypsy moth. The material used is kerosene, placed in a tank well elevated on wheels, and used precisely as in spraying, except that the nozzle is of iron and the spray of kerosene is ignited, and instead of a spray of fluid is substituted a spray of flame. It seems to me that with something of this sort, properly regulated and manipulated so as not to injure the vines, the latter could be first jarred, so as to cause the beetles to drop to the ground, and this flame turned on to them before they could crawl away, thus cremating them. I know nothing as to the probable cost of this measure, but it would not appear to be necessarily great, and it could be used even better in wet weather than in dry.

It was my intention to carry out a more elaborate series of experiments with the spring application of bisulphide of carbon, and also with the use of arsenical poisons in June, but so many other problems have claimed attention, and without any assistant, except for a couple of months, it has been found impossible to do so. It, therefore, seems best to give here what has been learned by what has, so far, been done, in order that those directly interested may be able to take advantage of the information so far obtained.

SUMMARY.

The Grape Root-worm is the young of a small, brown beetle, that emerges from the ground, in the vicinity of Cleveland, Ohio, from the latter part of June until September, but largely during July, feeding on the leaves and depositing its eggs under the bark of the vines. These eggs hatch out minute worms, of a white color with brownish heads, which drop to the ground and make their way to the roots upon which they feed, when full grown constructing earthen cells in which the larger portion pass the winter, advancing to the pupal state in June without feeding in spring, the pupæ developing adults as stated above. There is but one annual brood. The natural enemies, so far as now known, attack the eggs only.

The beetles can be poisoned by very strong solutions of the arsenical poisons, and the worms can be killed with the fumes of bisulphide of carbon. Frequent stirring of the soil during July, and keeping a thick covering of mellow earth over the roots during this period, will also be of service in preventing the young from reaching the roots.

APPENDIX.*

A NEW GENUS AND SPECIES OF PROCTOTRYPIDÆ AND A NEW SPECIES OF BRACHYSTICHA, BRED BY PROF. F. M. WEBSTER.

BY WILLIAM H. ASHMEAD.

FAMILY PROCTOTRYPIDÆ—SUB-FAMILY PLATYGASTERINÆ.

Fidiobia, gen. nov. Head transverse, as wide as the widest part of the thorax; viewed from in front, wider than long; the frons smooth, subconvex, ocelli three in a triangle, the lateral much nearer to the eye margin than to the front ocellus; the antennæ inserted near the mouth, in eight-jointed, ending in an ovate three-jointed club; the scape subclavate as long as the face, the pedicel cyathiform, a little longer than thick at apex; the funicle three-jointed, the first two joints not or scarcely longer than thick, the third wider than long. Thorax subovoid, a little longer than wide, the mesonotum smooth without sharply defined furrows, although these are more or less slightly indicated posteriorly by two longitudinal impressions; scutellum lunate, flat, separated from the mesonotum by a delicate transverse line, but without fovea; metanotum with two minute foveolæ; wings hyaline, without nervures.

Abdomen sessile, oblong, truncate behind and a little narrowed toward the base, the first segment wider than long, the second occupying the whole of the remaining surface, the terminal segments evidently being retracted.

This genus should be placed in my table, Monogr. N. A. Proctotrypidæ, p. 263, between *Anopedias* Forst. and *Amitus* Haliday.

It agrees with the latter in having eight-jointed antennæ, but their structure is totally different. They are very short and the club is three-jointed; while in *Amitus* they are long and the club is unjointed; otherwise, in shape and structure of thorax and abdomen, there is not a particle of resemblance, these characteristics more closely resembling those in *Anopedias.*

It also bears some resemblance to the genus *Phanurus* Thoms. in the tribe *Telenomini*, but it evidently cannot be placed here on account of the veinless wings and the structure of the abdomen, although its habits would seem to indicate an affinity with this group.

Fidiobia flavipes, sp. n. Female, length, 0.6 mm. Black, polished; legs and antennæ yellow; thorax without distinct furrows, smooth, with only slight indications of furrows posteriorly, but not sharply defined; wings hyaline, veinless; abdomen oblong, sessile, the first segment wider than long, the second very large, occupying most of the remaining surface, the following being usually retracted with it, and thus making the abdomen appear truncated at apex.

Hab.—Euclid, Ohio.

Described from specimens bred by Prof. F. M. Webster, July, 1894, from the eggs of a Coleopteron *Fidia viticida* on grape-vine.

FAMILY TRICHOGRAMMIDÆ.

Brachysticha Forster.

Brachysticha fidiæ, sp. n. Female, length, 0.65 mm. Head, except eyes and thorax, pale brown or brownish-yellow; the conical-shaped but depressed abdomen dark fuscous or black; wings hyaline, broad, pubescent, with a short marginal fringe, the pubescent not arranged in regular rows; legs brown or fuscous, the tips of femora, tips of tibiæ and tarsi yellowish.

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*These descriptions, together with the more technical portion of this bulletin, were first published in the Journal of the Cincinnati Society of Natural History, for October, 1894. F. M. W.

The head antero-posteriorly very thin, with a facial impression; the antennæ inserted far down on the face, six-jointed (scape, pedicel, ring-joint and a three-jointed, fusiform, pubescent club); thorax with a longitudinal median impressed line; while the abdomen is long, conically-pointed, but depressed above.

Hab.—Euclid, Ohio.

Described from specimens bred by Prof. F. M. Webster, August, 1894, from eggs of *Fidia viticida* on grape-vine.

This species comes nearest to *Trichogramma acuminatum*, Ashm., Can. Ent., 1888, p. 107, which should probably be referred to this genus, but differs decidedly in the color of the legs and abdomen.

EXPLANATION OF PLATE.

Fig. 1. A, *Fidia viticida* Walsh, adult; B, pupa; C, larva. Lines indicate natural length. *a*, head of larva from above; *b*, mandible; *c*, antenna; *d*, head of larva from beneath; *e*, maxilla; *f*, labial palpi.

Fig. 2. *a*, ovipositor of female, showing lateral view of extended terminjoint, with ova in ovaduc;* *b*, vertical view of extended ovipositor; *c*, ditto, with terminal section retracted.

Fig. 3. Appearance of leaf attacked by adult.

Fig. 4. Eggs as deposited under bark by female, the bark being partly removed.

Fig. 5. Appearance of root attacked by larvæ.

Fig. 6 Section of small root from Fig. 5.

Fig. 1, was drawn by Mr. Otto Heidemann; Fig 2*a*, *b*, *c*, by Miss Freda Detmers; Figs. 3, 4, 5, 6, by Miss V. D. Cunningham.

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* Fig 2*a* is drawn from amputated ovipositor of female, taken in the act of ovipositing, and the pressure necessary to prevent her from retracting it may have had something to do with the position of the egg.

BULLETIN

OF THE

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NUMBER 63. November, 1895.

ORCHARD SPRAYING.

BY W. J. GREEN.

The following notes on fruits of different kinds were prepared during this and former seasons and it was at first intended to publish them in separate parts, as material was collected, but the edition of Bulletin 48 on spraying, as well as one sent out as early as December, 1891, having become exhausted it has become necessary to prepare another devoted wholly, or in part, to that subject. It is thought best, however, to incorporate these fruit notes along with directions for spraying.

APPLES.

It has been pretty fully demonstrated that the failure of apple crops in recent years is due largely to the destructive action of the apple scab fungus, on flowers, fruit and foliage.

It was noted in the Bulletin of this Station for December, 1891, by Mr. U. T. Cox, of Lawrence county, who conducted experiments in the orchard of Nelson Cox, his father, that the foliage is preserved by spraying, and the same effect was observed at Columbus, but in a more marked manner, in the following season. Similar results have since been noted, particularly in 1894, in the Station orchard, and more strikingly in Mr. F. P. Vergon's orchard, in Delaware county. Along with this action of fungicides in preserving the foliage, has been noted, in every case, the fact that there has been less premature dropping of apples from sprayed than from unsprayed trees. It is also a fact that treatment has increased the size of fruit. The most striking illustration was found in 1894, in Mr. Vergon's orchard. From an unsprayed tree of Rome Beauty one and one-fourth bushels of rather inferior apples were picked, while from a sprayed tree of the same size, growing alongside, there were gathered six and one-half bushels of fine fruit, worth at the time at least $3.00 more than the fruit from the other tree. This is an extreme case, but the same cause operated, in a greater or less degree, in all the orchards of the State.

The trouble seemed to grow worse, gradually, and to culminate in 1893. In 1894 there seemed to be a slight improvement in some sections, and in 1895 all orchards, so far as observed, were nearly free from the disease. In our own experiments in 1895 no result was obtained in spraying for the apple scab, and so far as known, unsprayed trees have yielded as fine fruit as those which were treated.

The early part of the season was cool and very dry, and the latter condition prevailed up to the time of picking. There were a number of showers during the spring and summer, but they were mostly light and passed quickly, damp, cloudy days being very few. Under such conditions the apple scab fungus could not develop, and it was hard to find any evidence of it until late in the season, but even then it was not noticeable. It did no harm to either fruit or foliage, and to the unpracticed eye unsprayed fruit was as fine as that which had been sprayed.

This raises the practical question, what may we expect in the future, and is it advisable to spray or not to spray? The scab fungus is not killed out completely, but it is not possible to predict how long a time it will require in which to develop sufficiently to do serious harm again. Much depends upon the weather, which cannot be foretold.

Such conditions as those of last season are very rare, and damp weather is more likely to occur than not in spring and early summer. One or two such seasons may bring our orchards back again to the same condition as that previous to 1895. Nature has done more for the apple grower in a single season than any number of spraying machines could in all time, even though the condition which now presents itself is not a permanent one. It is one which may be taken advantage of, however, and it is clearly the part of wisdom to do so.

It is well known that it is the part of a fungicide to prevent rather than to cure, hence it will be much easier to hold the disease in check from now on than to get it under control after it is once established. It has been partially controlled on bearing trees, even in bad seasons. In our experiments in applying a fungicide to young trees from the time of planting, which have been carried on three seasons, the results are already evident; but now, of course, all are brought to the same condition, both sprayed and unsprayed, and we must start anew.

The result thus far, however, plainly indicates that the course to pursue with young trees is to begin spraying them as soon as planted, using the same preparation against fungi as advised for bearing trees. Even if this use of fungicides were of no practical value the improved looks of the trees in the clean, bright appearance of the bark is sufficient to warrant the small amount of labor required to spray young trees. It will pay, however, to spray young apple trees because of the reduction of labor in the future, and because of the greater certainty of results which will attend continued efforts in this direction.

No experiments have been conducted here to test the efficacy of the arsenites against the apple worm, as that matter has been considered as settled. Two sprayings have usually been recommended, with Paris green or London purple, one just after blooming and the other within a week or ten days following. There has been complaint that this does not answer the purpose, to the extent desired, and this agrees with our experience. We have added six ounces of Paris green to each barrel of Bordeaux mixture, after the fruit has set, making two applications in this manner. This has not given satisfactory results in checking the apple worms, but the past season two additional sprayings were made with Paris green, with evident benefit. Seventy-five to eighty-five per cent. of apples free from worms were thus secured. A caution must be added, however, as there is danger in the use of arsenical poisons after the apples have turned down so as to make a lodging place for the poison around the stems of the apples, especially in case of the early kinds. The matter is referred to here merely to give a hint to those who have not had satisfactory experiences in spraying for the apple worm, with the hope that with a little more thoroughness better results may be secured.

The matter of thoroughness is one that needs attention in all cases. There is but little use in beginning to spray for either insects or diseases unless careful attention is given to details and the work is thoroughly done. When performed as it should be there is no work on the farm that pays better, and to the professional fruit grower the spray pump is as essential as the cultivator. Some seasons it is more useful than others, but he cannot afford to take the chances of loss, at any time by neglecting to spray.

Regarding the number and dates of sprayings which should be made to apple trees, it is not possible to lay down general rules. Instead of observing dates it is better to be guided by the stage of growth, and the number of applications will be governed by the weather and the variety. Spraying should be more frequent in wet weather than in dry, not merely for the reason that the rain washes the mixture off, but because the fungus develops more rapidly under the first named conditions, than when the supply of moisture is scanty.

It is well to make two sprayings before the time of blooming, and if the weather is damp and the trees are late in showing bloom it will do no harm to add a third. The first should be made before the leaves are open, at which time the quantity of mixture required is small, and the work is quickly done. These are considerations in favor of spraying early aside from effectiveness, and taking all things into account there are abundant reasons for beginning operations in good season. There are also reasons for making an end of the work at the earliest date possible. Grimes' Golden, Maiden's Blush, Belmont and Ben Davis, and no doubt other varieties, are injured by the mixture; it having the effect of causing a roughened, russet appearance on the skin of the apples, if used too late in the season. One spraying after the apples have set is about all that these varieties will endure, without considerable disfiguration. Most others that we have tried do not show much injury, even if sprayed twice after the fruit is set. The effect noted does not affect the growth of the apples but injures the appearance merely, and may in some cases, detract from the market value. Although not a matter very serious in consequence it is well to guard against it and to prevent whatever loss might occur.

Whenever Bordeaux mixture is used after the apples have set it is well to add six ounces of Paris green to each barrel of the mixture, and to continue the use of the latter alone once or twice thereafter. It will be seen that the above is very nearly the same as the course formerly advised for the use of Bordeaux mixture on apple trees, nor does it differ very materially from that recommended by other experimenters, but still we should like to make it plain that we think it best to do most of the spraying to prevent the apple scab before the trees bloom, and to do just as little thereafter as need be.

There is considerable difference in the susceptibility of varieties of apples to the scab, and as might be expected, spraying does not benefit all alike. Locality exerts an influence also, especially differences in elevation. The following notes are made from experiences with varieties that have come under our observation:

Baldwin.—Seems not to be very subject to the disease, and, so far as we have observed, spraying has not benefited it greatly. In some cases the fruit appeared to hang on better where the trees were sprayed than if not. Spraying has been beneficial to the foliage in some cases, which is of indirect value to the fruit. From present indications it does not seem that spraying will extend the limit of the Baldwin very much to the southward, although such a result might reasonably be expected if spraying does, in all cases, cause the fruit to hang on the trees later in the season.

Belmont.—This variety is very subject to the scab and is greatly benefited by the application of Bordeaux mixture. As before stated, however, but one application should be made after the blossoms fall, because of injury to the fruit if used later than that.

Benoni.—The fruit of this variety has been very much improved and not injured, by spraying with Bordeaux mixture, but the treatment has not seemed to have much effect on the foliage.

Ben Davis.—A very marked effect was noticeable in southern Ohio, on the foliage of this variety, when sprayed. The fruit does not seem to be very much injured by scab, but the foliage is more susceptible to the disease than any other that has been noticed, except Rome Beauty. The fruit has been very much injured in appearance by over spraying, and it seems proper to give special caution not to spray it more than once after the fruit is set.

Early Harvest.—The same remarks apply to this as to the Belmont.

Grimes' Golden.—This variety does not seem to suffer greatly from the scab, and we have not seen much benefit from the treatment given it. Some injury has been done the fruit, but this has not been very marked.

Jonathan.—We have not had a very good opportunity to note the effect of spraying on this variety, but the results have been negative.

Maiden's Blush.—This variety is also very subject to the apple scab, and spraying has had a marked effect in improving the appearance of the fruit, and increasing both size and quantity. Some damage has been done to the fruit when over sprayed, but not so much as in the case of the Belmont.

Newtown Pippin.—No variety that we have sprayed has responded more satisfactorily and given greater profit for the labor expended than this. It is not far from the truth to say that without treatment this valuable variety is practically lost to the orchardists of the State, and our experiments show that it may be restored by the use of Bordeaux mixture. Both foliage and fruit suffer from the disease. Some damage to the fruit has been done by spraying, but it was hardly noticeable.

Northern Spy.—This is also a susceptible variety to the scab, and is greatly benefited by spraying. Although the fruit hangs on better if sprayed, and keeps better, than when not treated, it is still practically a fall apple in most parts of the State. We have found it more difficult than most kinds to keep free from the apple worm, and one of the easiest on which to control the scab.

Peck's Pleasant.—We have had no marked results in spraying this variety. In some localities, especially on low lands, the skin shows a dingy or smoky appearance, owing to the presence of some fungus, and this is removed by spraying, but further than this no improvement has been noted, although full opportunity has not been had for experimenting upon it.

Rambo.—This variety has been almost a failure in most localities on account of the scab, because of the effect both upon fruit and foliage.

We have not had full opportunity to experiment upon it, but it is benefited by the treatment, and the injury to the fruit is not great.

Red Canada (*Richfield Nonesuch*).—The same observations apply to this as to the Rambo. There seems to be no reason why this choice variety might not be restored to its former estate by spraying.

R. I. Greening.—We have not experimented fully with this variety, but it is less subject to scab than most others. On low lands it has the same discoloration found on the Peck's Pleasant and Rome Beauty, which spraying removes.

Rome Beauty.—This variety is very subject to the scab, and on low lands the fruit is badly discolored. There is also a marked contrast in the appearance of the fruit on the lower and upper branches. The foliage suffers more than the fruit, hence where spraying is practiced there is a marked improvement in condition of the leaves, and the fruit is increased in size accordingly. No variety that we have experimented upon has yielded better results than this in the improvement of the fruit in color and size, and increase in quantity. The mixture does not injure the fruit to any extent.

Roxbury Russet.—We have not noted any advantage in spraying this variety.

PEARS.

Essentially the same course is advised for pears as for apples. Still more care must be taken not to spray too late, however, as the fruit of some varieties is easily injured by the mixture, causing the same russet appearance which has been noted as occurring on apples. This has been noted more particularly on the Angouleme than any other sort and to a less extent on the Bartlett.

The varieties most benefited by spraying, according to our observations, are White Doyenne and Flemish Beauty, to prevent cracking; Vicar and Angouleme. to prevent the smoky or smutty appearance so common to these sorts; Clairgeau and Bartlett, to prevent premature leaf dropping. Of course all the troubles occur on all of the kinds named, and others as well, and the remarks are intended merely to call attention to distinguishing features.

PLUMS.

Most varieties of plums are subject to premature leaf dropping, which prevents the proper ripening of the fruit, and tends to debilitate the trees, and spraying with Bordeaux mixture has been found to be decidedly beneficial.

On this point there seems to be no difference of opinion, and our former recommendations have been fully sustained, but not all orchardists have been successful in keeping the curculio in check with Paris green alone, nor in combination with Bordeaux mixture. This may be due to several causes, but principally to the fact that there have been some unwarranted expectations regarding the matter. Many have thought that if the curculio can be controlled in an orchard, by spraying, that the same thing can be done on a single tree, or a few trees. Quite as unwarranted has been the belief that the treatment ought to work on a small plum orchard, surrounded by peach, and other orchards.

That the curculio can be held in check by spraying has been fully demonstrated, but when the difficulties are increased beyond a certain limit by contiguity with unsprayed trees, the method becomes partially or wholly impracticable. Four applications of Bordeaux mixture and Paris green combined will usually answer in the case of an orchard somewhat isolated, but more sprayings with Paris green must be given if other trees, which harbor the curculio, are close at hand and are left unsprayed. This is not always advisable, because of possible injury to the foliage. The latest and best plan, is to spray three or four times with Bordeaux and Paris green, and then to follow with the curculio catcher as often as need be. In this manner the foliage is preserved and the curculio given a check as well. Finishing with the curculio catcher gives a chance to gather and burn the plums that may be stung. There is a saving in time by this method, besides the other advantages named.

PEACHES.

The foliage of both peaches and American plums is easily injured by spraying, hence the mixture should be reduced about one-half. One application may be made full strength, before the leaves open, and one or two latter, half strength. A full discussion of this subject will be given by the Botanist, in a Bulletin on Peach Diseases.

SPRAYING MIXTURES.

Bordeaux mixture.—This is by far the most important fungicide; so much so that other preparations are used in rare and exceptional cases only. This Station was one of the first to call attention to the value of the dilute Bordeaux mixture for apple scab, and to fully demonstrate its value for this and other purposes. Formerly a much stronger preparation was used, which was somewhat troublesome and quite expensive, hence various other fungicides were employed, but since the value of the weaker Bordeaux mixture has become known it is recommended almost exclusively by experimenters. The formula is varied somewhat, but as used here the ingredients and proportions are as follows:

Copper sulphate (blue vitriol)	4 pounds.
Quick lime	4 pounds.
Water	40 to 50 gallons.

It is safer to buy the copper sulphate in the form of coarse crystals, as the pulverized may be adulterated, although not necessarily.

It is advantageous to pulverize it before using, however, for the purpose of saving time in making a solution. There is a saving of time in using hot water in making a solution, taking a gallon of water to a pound of the crystals.

If the crystals are put directly into the water, solution takes place very slowly, but if suspended in a sack near the top of the water, they dissolve more rapidly. The lime is slaked by pouring water over it slowly and then adding sufficient water to make a milk of lime. It may be slaked in a common wooden pail, and the milk of lime poured off into the copper sulphate solution, leaving the coarser parts of the lime in the pail, after which water is added and the milk of lime poured off as before, rejecting all the lime which may be left after water has been added two or three times.

The actual quantity of lime required is not so much as is advised, but time is saved by taking more than is needed, rejecting that portion which is not readily acted upon by the water. If the lime is fresh, and of good quality, there can be little danger in following this method. No harm follows in case there is an excess of lime, but if the reverse should happen, and there is an excess of copper sulphate, the foliage of trees sprayed will be seriously injured.

The potassium ferrocyanide test has been proposed in order to determine just how much lime to use, but it appears not to be always reliable, nor does there seem to be any need of it, if the lime is fresh.

The question is often asked: Can Bordeaux mixture be kept any length of time without spoiling? No doubt it may, but such a course is not practicable, for after standing a few days, it is apt to give trouble because of the sediment which forms. The fresh mixture works in the pump and sticks to the foliage so much better than that which has been kept a few days that it is just as well to throw away all that is left at any time, unless operations are to be resumed within a few hours.

Stock solutions of copper sulphate and milk of lime are often prepared beforehand, so that by taking a specified quantity of each much trouble in weighing and dissolving is saved. By dissolving the copper sulphate at the rate of one pound to a gallon of water, four gallons would need be taken each time a barrel of the mixture is to be prepared, and the lime might be treated in the same manner. Still stronger solutions are practicable. One case has occurred, however, where foliage has been injured by following this plan. Whether this happened because of some mistake in the proportions, or a chemical change took place in the lime while standing, is not known. The plan is quite extensively practiced in many sections and will probably come into general use where large operations are carried on.

Ammoniacal solution of copper carbonate.—This is easily prepared by dissolving copper carbonate in ammonia and diluting with water. Two quarts of ammonia will usually dissolve six ounces of copper carbonate, but as ammonia varies in strength more may be required. After solution water is added to make a barrel of the preparation.

Potassium sulphide (*liver of sulphur*).—Dissolve one ounce in four gallons of water.

White hellebore powder.—One ounce to three gallons of water.

Paris green and London purple.—One ounce to ten gallons of water, except where noted.

WHY AND HOW TO USE THE ABOVE PREPARATIONS.

In order to bring all together, for the sake of convenience in reference, some of the directions already given will be repeated in a condensed form.

Apple Trees.—Spray to preserve the foliage and fruit from the scab, to increase the size of the fruit, to heighten its color and to improve its keeping qualities, also to destroy the apple worm.

Use the Bordeaux mixture before the leaves open, and again just before the time of blooming. Repeat just after blooming, adding six ounces of Paris green. In case of varieties that are not injured by the mixture make another application in about a week. It is well to apply Paris green once or twice more, using the regular strength.

Pear Trees.—Spray to prevent premature leaf dropping and cracking of the fruit; to improve the size, color and keeping qualities, and to check the curculio. Follow the same course as advised for apples.

Plum Trees.—Spray to prevent leaf dropping, and to check the curculio.

Use Bordeaux mixture and Paris green combined, making three or four applications, about a week apart, commencing as soon as the blossoms fall.

Cherry Trees.—Spray for the curculio and slugs, also in some cases to prevent premature leaf dropping. Use Bordeaux mixture and Paris green, half strength, twice after the fruit is set.

Quince Trees.—Spray for fruit spot and leaf blight. Use Bordeaux mixture two or three times after the fruit is set.

Grape Vines.—Spray for grape rot and anthracnose. Use Bordeaux mixture once before the leaves appear, and again before blooming, and twice after the fruit has set, after which substitute the ammoniacal carbonate of copper for two or three sprayings. Unless spraying is begun early and continued until the grapes are fully half size the treatment is not likely to prove very beneficial.

Raspberry Plants.—Spray for the anthracnose. Use Bordeaux mixture once before the leaves open, after which apply it two or three times, half strength, to the young canes only, taking care to keep the mixture off the leaves of the old canes. We have succeeded with this treatment, but many others report indifferent results, for reasons which cannot, at present, be explained.

Gooseberry Plants.—Spray for the mildew and currant worm. Either Bordeaux mixture or potassium sulphide applied two or three times, will prevent the mildew, but the latter is preferable if used when the fruit has attained considerable size. Paris green is often employed to kill the worms, but its use is not advisable, unless great care is taken not to get it on the fruit. White hellebore, either dry or in water, is the best insecticide for this purpose. The time to use it is when the worms are very small and have just begun operations.

Currant Plants.—Use white hellebore for worms the same as above.

APPLIANCES USED IN SPRAYING.

This part of the subject was not touched upon in the last Bulletin, but so many inquiries have been received relating to it that it seems necessary to treat somewhat briefly.

To apply the various mixtures in the form of a spray, a good force pump is needed, and should have all of the parts with which the mixture comes in contact made of brass, or some material that will not corrode. The Deming Co., of Salem, O.; F. E. Myers & Bro., of Ashland, O.; The Humphreys Manufacturing Co, of Mansfield, O., and the Nixon Nozzle and Machine Co., of Dayton, O., as well as several firms outside the State, make good pumps. The same pumps are sold by seedsmen generally, and by most dealers in hardware. It is not a difficult matter to get a good pump, but all dealers do not keep on hand the best hose, nozzles and other necessary appliances.

The Bean-Chamberlain Manufacturing Co., of Hudson, Mich., make a pump with a large air chamber, which has certain advantages. Although the pump itself does not work any easier than most others, and does work harder than some, yet the man who does the pumping finds that he can keep up a better pressure than with a pump having a small air chamber. He does this by getting up a good pressure before the other men begin spraying, and then a few strokes at frequent intervals will keep it up without such continued effort as with pumps having a small air chamber. The men holding the hose like the pump because the pressure is uniform. It is rather higher in price than most other pumps.

The accessories or appliances which go with the pump are as necessary as the pump itself, and unless these are of the best kind and quality spraying cannot be carried on expeditiously. One man can pump for two or more men to spray, but usually two work to the best advantage, each having charge of a hose attached to either side of the pump.

The hose may be one quarter or one-half inch, but ought not to be larger, and should be of the best quality of rubber, linen insertion, four or five ply. Twenty-five feet of hose is about the most convenient length for spraying apple trees. To this is attached about ten feet of one-quarter inch gas pipe, on the end of which is the nozzle. The B. F. Goodrich Co., of Akron, O., made to order the best hose that we have ever been able to secure, and no doubt other manufacturers of rubber goods can make as good if told just what is wanted, but the hose commonly kept in stock by dealers is seldom satisfactory. An iron gas pipe is as good as brass tubing which was formerly recommended, with the difference that the iron pipe will be found to be full of scales the second season, and at the beginning of each season thereafter. This must be attended to before beginning work, or the scales will clog the nozzles.

The Vermorel nozzle, made by the Deming Co., suits our purpose better than any other. The McGowan nozzle projects a spray farther, but we use the first named almost altogether. It becomes necessary, in spraying large trees, for the men to climb part way to the top, in order to do good work, but most of the spraying is done from the ground. The pump is mounted on a cart, but it might be placed in a wagon, and many prefer this plan, especially if one man pumps for one but other to spray. If possible a pump with an agitator should be obtained, but in case no other plan is feasible a paddle must be frequently used to stir the liquid. To return a stream from the pump is not satisfactory. Various modifications in the above recommendations as to outfit for spraying will suggest themselves, and each one must adapt the means to the conditions. Knapsack and bucket sprayers are useful in a limited way, for vines and brushes, but the general purpose sprayer is some modification of that described above.

NOTES ON VARIETIES OF RASPBERRIES.

All Seasons.—A red variety, which produces a moderate crop in the regular season, and frequently gives a second crop very late. The plants are very strong and sucker freely; the berries are from one-half to three-fourths of an inch in diameter, moderately firm and of good quality. The principal objection to the variety is that it does not produce sufficiently early in the season, to be of any value as a market sort. The late crop might be of some value for home use were it reliable and abundant enough. Taking all things into consideration it is difficult to find enough of value in the variety to recommend it.

Champion.—A small, early blackcap, not in any way superior to Souhegan.

Champlain.—A yellowish white variety of the Antwerp class, and needs protection in this latitude. The berries are soft, and are not produced abundantly enough for market purposes, but their fine quality entitles the variety to a place in an amateur's collection.

Columbian.—A purple variety of the same general appearance as the Shaffer. The resemblance between the two is so close that many have considered them to be identical. The Columbian is quite generally admitted now to be superior to the Shaffer in being less subject to anthracnose and a stronger grower, while the berries are firmer and superior for both canning and evaporating. Whether all of the claims which have been made for the Columbian will be sustained cannot be known without further trial, but it seems safe to say that it will supersede both Shaffer and Muskingum, and stand as the best representative of the class.

For the benefit of those who have not given such matters attention it may be well to explain that the Columbian roots from the tips of the branches, the same as blackcap varieties, and that while the fruit is purple in color it has much the same flavor as the red raspberries. It has the advantage, then, over the ordinary red sorts that it does not sprout from the roots. To the farmer, or one who grows berries for home use only, this is an advantage; but to the fruit grower it is of less importance. For canning it excels most red sorts, as the berries do not fall apart so much in cooking, and in flavor it is equal to any. For market it will prove valuable in localities where berries of such color are in demand, but it is particularly to be recommended for home use. It has now been sufficiently well tested so that no one need have any fear in giving it a trial.

Cuthbert.—A well known and reliable red variety. It is not hardy at Columbus but it seems to be so here, and good reports from it are almost general.

Eureka.—An early blackcap of great value. In season of ripening it may be classed as early, the first picking coming about with the second picking of the Palmer. The last picking is as late as the last of the Gregg, thus covering the season of both, giving good pickings all the time. More will be said concerning this variety under the head of Mohler.

Early King.—A valuable red sort, coming just after the Thompson, but earlier than most red kinds. Plants strong and fairly prolific; berries large, of bright color and good quality. May prove valuable for market.

Gault.—A blackcap of the everbearing class. Although this variety has been under observation two seasons, there is still a doubt as to what estimate to put upon it. Our one-year plants fruited but little this season because of injury from frost. It was hurt more by frost than any other variety, but whether because of tenderness or because it happened to be in bloom at the time when frost came the hardest cannot be stated. More than that it has not shown the everbearing habit here. We have nothing, therefore, to offer from our own experience with the variety. It was the opinion of the Horticulturist of the Station that, as seen on the originator's grounds, the principal merit of the variety consisted not in its everbearing habit, but in its ability to produce a good crop at the usual season, when other varieties are in fruit, and of continuing the season even beyond the ordinary date. That is, it appeared to be a promising late variety, even later than Gregg. It surely is a heavy cropper, and the berries being very firm, ship well and are well adapted to drying. Others have seen much to praise in its everbearing habit. Compared with other known kinds which have this peculiarity, it seems to excel them all in quantity of product. It must be classed as a promising variety, notwithstanding its behavior here.

Gregg.—This is still the standard late variety.

Kansas.—This is a valuable variety, and many good things could be said concerning it. It comes in competition with Eureka, however, which is its superior in some respects, being earlier and more prolific. For this reason it is not possible to accord the Kansas the place which many think that it should occupy.

Lotta.—A medium to late blackcap of very great promise. Plants are very strong in growth, healthy and prolific. It excels the Gregg in growth and productiveness, while the berries are slightly larger and darker in color. It begins ripening a few days before the Gregg. It is hard to find fitting words to express an opinion of this variety without seeming to overpraise it. It has been fruited both here and at Columbus, and its behavior has been such as to leave no doubt as to its great merits. There remains, of course, the possibility that it may not do as well elsewhere, but varieties of such vigor and good health are not usually hard to suit as to soil and climate. It ought to be tried by fruit growers generally.

Loudon.—This has been seen here on young plants of one season's growth only. The berries are large and of fine appearance, but no opinion concerning its value can be given.

Mills' No. 7.—A large, midseason blackcap. The berries are large and cluster very closely at the end of the shoots, making picking rather difficult. It continues in ripening a comparatively short time, which some would consider objectionable, as short season varieties do not, as a rule, give as large yields as those which take a longer time in which to mature their crop. Some growers, however, prefer varieties which mature their crop within a very short time, following with other later, short season sorts. It is an open question which course is the better, but the opinion may be expressed that those who follow the latter plan sacrifice something in yield per acre.

Mills' No. 15.—A midseason blackcap, of about the same season and size as the Ohio. Its principal merit is firmness, fitting it admirably for shipping or drying, but to sell fresh in near market there are many others which are superior to it.

Mohler.—A blackcap, identical with the Eureka. There has been considerable controversy as to whether these names represent the same, or distinct varieties. The whole discussion cannot be given here, but enough, simply to show the reasons for the ground taken. In 1890 the Eureka was sent to the Station for trial, by Mr. J. C. Kester, of New Carlisle, O. In 1891 Mr. D. M. Mohler of the same place wrote to the Station, making inquiries relative to the merits of the raspberry sent by Mr. Kester. A reply was sent by the Horticulturist, and the following card was received from Mr. Mohler in acknowledgment:

New Carlisle, O., *Apvll* 6, 1891.

"Dear Sir: Very much obliged for report on J. C. Kester Raspbery, which is now being introduced by name of Mohler's No. 1 Raspberry."

(Signed.) Mohler, Taylor & Co.

This and subsequent conversations with Mr. Mohler, led the Horticulturist to believe that the name Eureka had been dropped and Mohler substituted, for good reasons. Mr. Mohler distinctly stated in 1893 to the Horticulturist that he owned all of the stock of the Eureka and had changed the name. A few months later several letters were received, stating that Mr. Mohler now claimed that they were distinct, which was the first intimation of the kind received by the Horticulturist. In 1894 Mr. W. W. Farnsworth and the Horticulturist visited Mr. Mohler, and then learned that he claimed the Mohler to be a seedling of the Eureka, and much superior to it.

Several Eureka raspberry plantations were visited during the same trip, and the impression carried away was that the two were practically identical, even though one might be a seedling of the other, and this was the substance of the report made to the State Horticultural Society. Plants under both names have been fruited at the Station two seasons, and no differences have been discovered.

It is hard to reconcile Mr. Mohler's statement, that the Mohler is a seedling of the Eureka, with his postal card, and with other admissions; but should this be done, and he be able to prove that he did not rename the Eureka, and that his variety is a seedling of the latter, there still remains the fact that one cannot be distinguished from the other. The claim that the Mohler is an improvement upon the Eureka has not the slightest foundation, hence there is no reason why the former should be sold at a higher price than the latter, and the name Eureka is the only one that should be recognized. The postal card, above quoted, was slipped into the wrong place in the letter file, and could not be produced in evidence at the proper time.

Older.—A midseason blackcap of considerable merit, but not sufficiently distinct from other sorts to make it specially valuable.

Palmer.—This is still regarded as the standard among extra early blackcaps.

Pride of Kent.—A red variety of some merit, but lacking in productiveness. The plants are vigorous, the fruit is of good size and color, but not sufficiently abundant.

Royal Church.—A red variety, which has done well in some localities, but has not succeeded generally. It has been variable at the Station, sometimes proving satisfactory, but more often the reverse. The berries usually crumble in picking, but if this were not true, they are too soft for market, unless handled with great care.

Thompson.—This variety still sustains its reputation as an extra early sort. It commences to ripen early and matures the bulk of its crop within a very short time, making it particularly desirable where an early market is sought, but it must not be expected to take the place of more prolific midseason varieties.

Unnamed variety, from L. H. Reid.—A yellow sort, having fruit somewhat larger than Golden Queen, and not quite as firm. Possibly it may have some value for home use, but is not desirable for market.

SUMMARY.

The failures of apple crops in recent years have been largely due to the destructive action of the apple scab fungus.

This is shown by the fact that sprayed trees have often yielded fruit when others were barren, or partially so. In one case a sprayed tree gave about $3.00 worth of fruit more than an unsprayed tree alongside.

The trouble seemed to be at its worst in 1893, with some improvement in 1894, and disappeared almost wholly in 1895.

The cause of its cessation was the continued dry weather.

This condition cannot be expected to prevail beyond one or two seasons, and the former state of affairs may return at any time.

The office of a fungicide is to prevent the growth of fungi, hence the proper course to pursue is to take advantage of the present conditions, and to seek to hold the disease in check, by spraying.

It is advisable to spray young trees just planted, as well as those that are in bearing.

Two applications of Paris green have not kept the apple worm in check, but the past season four sprayings gave quite satisfactory results.

In spraying apple trees for the scab it is well to do as much of the work before the time of blooming as possible, and as little after that time as need be, because the mixture injures the appearance of some kinds, if used too late.

The Belmont, Benoni, Ben Davis, Early Harvest, Maiden's Blush, Newtown Pippin, Northern Spy, Rambo, Red Canada and Rome Beauty, are greatly benefited by applications of Bordeaux mixture.

Baldwin, Grimes' Golden, Jonathan, Peck's Pleasant, R. I. Greening and Roxbury Russet have not shown much improvement under the treatment.

Nearly all varieties of pears are improved by spraying, but not all in the same manner, and some are injured by late applications.

Bordeaux mixture is beneficial to plum trees, and the curculio may be held in check with Paris green, but the difficulty is increased in proportion as the plum trees are surrounded by other trees which harbor the curculio. At present it seems best to fight the curculio both by spraying and catching.

Peaches and American plums should be sprayed with half strength mixture, if applied when in leaf.

The most useful fungicide is the Bordeaux mixture, and in making it an excess of lime is advised. Copper carbonate and potassium sulphide are useful in a limited way, to replace the Bordeaux mixture where it cannot well be used.

Apple and pear trees should be sprayed with Bordeaux mixture twice before blooming, and once or twice after, according to variety, using six ounces of Paris green to a barrel of the mixture, the third and fourth times. Two more applications of Paris green, four ounces to the barrel, are advisable in some cases.

Three or four applications of Bordeaux mixture and Paris green are advised for plum trees, after blooming, using the curculio catcher still later.

Two sprayings, half strength, of Bordeaux mixture and Paris green combined, are advised for cherry trees, after blooming.

Grape vines require three or four sprayings with Bordeaux mixture; two before the fruit sets and two after; and two applications of copper carbonate still later.

Raspberry plants should be sprayed once before the leaves open, with Bordeaux mixture, and the young canes two or three times later, with the same, half strength.

Either Bordeaux mixture or potassium sulphide may be used for the mildew on gooseberry plants, and white hellebore for the currant worm.

A spray pump should have the parts with which the mixture comes in contact made of brass, or some material which will not corrode. The appliances needed for spraying large trees are about twenty-five feet of good rubber hose and ten feet of tubing, on the end of which the nozzle is fastened. A large air chamber is helpful, and some form of an agitator is necessary.

The most desirable new varieties of raspberries are Columbian, Eureka, Kansas, Lotta, Thompson and Early King. Gault, Mills' Nos. 7 and 15 require further trial.

All Seasons, Champion, Pride of Kent and Royal Church are not desirable.

Mohler is a synonym of the Eureka.

BULLETIN

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THE SMUT OF OATS AND ITS PREVENTION.

BY AUGUSTINE D. SELBY, B. SC., BOTANIST.

The blackened panicles of oats, so conspicuous at blossoming time, have been observed by almost every person who has seen a field or plot of this grain. That this condition, known as smut, is a disease caused by the parasitic growth of a microscopic plant, the oat-smut fungus, is also generally known. It is only quite recently that successful and cheap prevention has been devised, a result of that spirit of experimental investigation, characteristic of our century. The smut of oats has been the subject of special investigation by Jensen,[1] by Kellerman and Swingle,[2] by Arthur[3] and by others.

The oats at this Station, especially in the variety plots, having become seriously affected with smut, and with apparent rapid increase in amount from year to year[4], experiments in treatment of seed were undertaken; later, with the maturity of the oats crop for the season, efforts were made to determine the amount of smut in different parts of the State. The results of these investigations seem worthy of publication; this conclusion has been reached in view of the considerable losses occasioned by smut in oats and the comparative tardiness with which methods of prevention have as yet found general application in this State. It appears at present, that seed treatment is a neglected source of profit in oats production, and the general realization of this profit is the problem here offered.

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[1] See Journal Royal Agricultural Society of England, 1888, Vol XXIV S. S., Part II, pp. 397—415.

[2] See Bulletins and Reports of Kansas Experiment Station: 1889, B. 8, 2d, An. Rpt.; 1890, B. 15; 1891, B. 22.

[3] See Report of Botanist New York Experiment Station, 1884, and Bulletins Indiana Experiment Station: 1889, B. 23; 1891, B. 35.

[4] Hickman, J. Fremont, Bulletin 57 (1895) p. 115.

HISTORICAL.

The oat plant, *Avena sativa*, has been cultivated almost or quite as long as the wheat plant; the references to smut in oats do not cover so long a period, apparently, as do those in regard to smut in wheat.[5] The earliest distinct mention, of which we possess information, is that of Tragus in 1552. In 1591 Lobelius[6] gave a figure of oat smut under the name of *Ustilago Avenæ.* The fungus was long known, later, as *Ustilago segetum* (Bulliard) Dittmar, und *Ustilago Carbo* Tulasne; for this period the loose smuts of wheat, barley and oats were regarded as identical. In 1888[7] Jensen named the loose smut of oats *Ustilago segetum* var *Avenæ*, and in 1889[8] *Ustilago Avenæ*, recognizing it as a separate species. This view is meeting with quite general acceptance. In accordance with botanical usage, we write *Ustilago Avenæ* (Persoon) Jensen, since pre-Linnæan names are not taken up. The botanical history of the smut fungus is thus necessarily interwoven with the occurrence of the disease it causes in this cereal.

The introduction of oats into the American colonies took place very early. It was sown in Newfoundland in 1522 and in the Colony of Massachusetts Bay in 1629[9]; good crops of oats are reported in Lynn, in 1633.[9] But while this early oats growing was probably attended by the occurrence of smut, we search almost in vain for early references to it. In the index to reports of United States Department of Agriculture, 1837 to 1876, the earliest mentioned article on oat smut is in 1873; references to wheat smut (stinking smut of wheat) are frequent in the index named, and in the files of early agricultural journals. In all these sources consulted there is the same dearth of information concerning oat smut. In this respect, however, we are no worse off than England. The earliest indexed reference to oat smut in the Journal of the Royal Agricultural Society, is the article by Jensen, before referred to. The edition of Ellis[10] examined makes no mention of smut in oats. It would be strange were there no earlier references to this smut in America, but the one "seen" bears date of 1820,[11] and refers particularly to rain-washing in the field as a preventive. Eight subsequent and successive volumes of the American Farmer make no mention of oat smut. The Cultivator[12] from 1846 to

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[5] Kellerman and Swingle, 2d An. Rpt. Kansas Exp. Sta., 1889, p. 215.

[6] Kellerman and Swingle, loc. cit., p. 215.

[7] Jensen, J. L., loc. cit., p. 407.

[8] Jensen, J. L., Le Charbon des Cereales, p. 4 (K. & S.)

[9] Report U. S. Com'r Patents (Agriculture) 1853, p. 158.

[10] Ellis's Husbandry, London, 1772, kindly loaned by Prof. F. M. Webster.

[11] American Farmer (Balto.) Vol. II, No. 27 [Sept. 29], 1820, p 215.

[12] Cultivator (Albany, N. Y.), Vol. IV Third Series, 1856, p. 139 and p. 158.

1865, appears to have two references to smut in oats. In the History of Vegetable Substances,[13] Vol II, the author, while treating of both wheat and oats with more or less of detail, and mentioning the commoner diseases of wheat, makes no reference to smut in oats. Fox[14] in his text book of Agriculture, makes this mention: "Smut (*black heads—Uredo Segetum*) appears to be the only fungus to which it (oats) is generally subject, and this, rarely to any extent". Instances might be multiplied to show how rarely attention has been called in the past to the disease, which appears to have been taken as a matter of course.

This old view bears emphasis in order to point out its fallacy; the tendency still seems to be in the same matter-of-course way. That the trouble has a specific cause and specific conditions of development, requires frequent repetition. It is apparently well proven that, without the presence of smut spores in the vicinity of the growing grain which is to furnish seed oats, or to a less extent, an adhesion of spores through threshing, no smutted panicles will occur. In the case under discussion only those spores which are within the husk of the seed oat seem capable of causing smut in the oat plant[15]. This is shown by the artificial smutting of seed just before the sowing. A very slight difference in the amount of smut produced, between plants from seeds smutted by dusting spores upon them and those from seed not so treated, has been observed by many experimenters. The reference just given to Jensen's work covers this point also.

The explanation appears to rest on the fact that the spores are disseminated at blossoming time. And since the spores adhering to the exterior of the kernel are, for the most part, ineffective in producing smut, it must be those spores which find entrance within the husk that cause the infection. "As the kernels of oats and barley are tightly embraced by the husk, except when the husk opens to allow the stamens to protrude, it follows that this period is the most favorable for the infection of the grain."[16] The spores are apparently not effective in producing smut the season they may find entrance. In our current year's work, four small plots were experimented upon to secure data upon this point. On two plots, spores were carefully dusted, at blossoming time, the operation being repeated to infect, if possible, all panicles; on the other two, no dusting was done. Practically no difference was found in the amount of smutted heads; the results of counts will be given later. The application of the matter, just stated, lies in seed selection or seed treatment after methods given in this bulletin.

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[13] History of Vegetable Substances Used in the Arts, etc., and for the Food of Man, Vol. II, Boston, 1833.

[14] Fox, Charles, Am. Text Book of Agric., Detroit, 1854, p. 105.

[15] Jensen, J. L, Propagation and Prevention of Smut in Oats and Barley, Jour. Roy Ag. Soc. S. S. II, 1888, pp. 401—403.

[16] Jensen, loc. cit., p. 403.

It is to the labors of Jensen, Kellerman and Swingle, Arthur and others since them, that we owe the marked recent progress in smut prevention in America, and the advance of experimental knowledge concerning smut infection.

DAMAGE CAUSED BY SMUT.

The effect of smut upon the oat plant, in this case the host, is generally confined to the grain and grain bearing parts, particularly the glumes. The smut has been found upon the leaves of oats grown in greenhouse from seed obtained at this Station,[17] and perhaps others have so found it. But the real injury with which we have to deal is that of grain destruction. The smut of oats, like other loose smuts, commonly converts the grain and its surrounding glumes or chaff into a black, powdery mass. See Figs. 2 and 3, Plate I. The dark, dirty aspect of the diseased panicles has given rise to the name "smut". When grains and glumes are both affected it is easy to distinguish the smutted heads upon their emergence; the whole is black and sooty with entire destruction of the grain. This may be regarded as the more common condition, both as to appearance and as to loss of grain in smutted plants. But the smut often destroys the grain without converting the empty glumes into dust. In some varieties this is notably the case. In Black Prolific the feature was noticed, also in Race Horse, and to a greater or less extent in all varieties. An extreme form of this sort, is that in which the flowering glume remains intact while the kernel within is smutted, the form called "hidden smut" by Kellerman and Swingle.[18] Where this hidden smut occurs, cutting through the spikelet will disclose it. One who has to do with this form, will soon note external characters which generally suffice to distinguish it without recourse to cutting open the glumes. Among these entirely smutted panicles with empty glumes intact, occur those in which the lower part of the head is smutted while the upper spikelets bear sound grains. See Fig. 1, Plate I. An extreme example was found in Race Horse, where the lower kernel of a spikelet was sound and the upper one destroyed by smut. Brefeld[19] appears to have offered a sufficient explanation of this partial smutting of heads by the upper portion's outgrowing the fungus mycelium and thus escaping infection.

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[17] Prof. L. R. Jones, Burlington, Vt., in letter of Dec. 7, 1895.

[18] Bulletin Kas. Exp. Sta., No. 20, 1890, p 100.

[19] Brefeld, Nachrichten aus dem Klub der Landwirthe zu Berlin No. 221, p. 1592; also Journal Mycology, Vol. VI., p. 154.

The smutted plants commonly have a normal appearance until just before blossoming. As the smutted panicles appear, the entirely dusty ones are very evident. At no later time is the smut in the plot of grain so conspicuous as near the close of the blossoming period. When the grain has ripened, the dusty spikelets will have shed their infecting spores; the straw stands stiff, erect, and somewhat greener than healthy straw. It is worthy of note that nearly all stalks of a smutted hill are smutted; the large number of stools in smutted areas suggests that the disease may produce abortive stooling, where the grain is badly affected. The total heads found in equal areas, as shown in the table (p. 136) offers like general evidence.

The oats grower is more directly interested perhaps in the destruction wrought by the smut.

AMOUNT OF SMUT AND LOSS OF CROP IN OHIO.

Since practically all smutted heads are lost to grain bearing, the per cent. which represents the actual proportion of smutted to the total number of stalks, will also give the part of crop lost by the disease. Perhaps this intangible part lost, stands somewhat in the background and is unappreciated, yet the proposition just stated with respect to amount of loss in crop, admits of easy mathematical demonstration.

From a bulletin by the Agriculturist of this Station[20], we find that the varieties of oats on the Station grounds, in which determinations were made, had the following per cent. of smut in 1894:

Black Prolific, 34 per cent.; American Banner, 13.9 per cent.; Race Horse, 19.1 per cent; Lincoln, 20.0 per cent.; Seizure and White Wonder, each, less than 1 per cent.; Welcome, 1.7 per cent.; Wideawake, 2.6 per cent.; Mammoth Russian (Cluster), 5.9 per cent.; Great Northern, 20.2 per cent.; White Superior Scotch, 21.7 per cent.; AN AVERAGE OF 14.53 PER CENT.

AMOUNT OF SMUT IN 1895.

A number of counts were taken in the oats at the Station in 1895, to determine the amount of smut in untreated areas. As will be seen these results are very high. The smut counts in 1895 are given in Table I:

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[20] Bulletin No. 57, pp. 114–115.

TABLE I.—SMUT COUNTS IN OATS AT OHIO AGRICULTURAL EXPERIMENT STATION, 1895.

Variety, location and other conditions.	Total stalks counted.	No. with smutted panicles.	Per cent. smutted.
§Australian Giant, variety plots	1,726	197	11.41
American Banner, smut plots	2,633	910	34.56
§Badger Queen, variety plots	1,591	107	6.73
§Barley Oats, variety plots	1,512	142	9.39
Black Norway, smut plots	1,995	902	45.21
Black Prolific, smut plots	2,557	794	31.05
Black Russian, variety plots	1,901	231	12.31
Calgary Gray, variety plots	2,084	257	12.30
§Centennial, variety plots	1,299	98	7.54
§Clydesdale, variety plots	1,671	61	3.66
§Colonel, variety plots	1,547	182	11.76
Early Archangel, variety plots	1,718	588	34.23
Everett's Negro Black, variety plots	1,747	432	24.73
§Hargett's White, variety plots	879	42	4.78
§Henderson's Clydesdale, variety plots	1,241	71	5.72
Lincoln, variety plots	1,942	627	32.29
Lincoln, smut plots	3,033	1,784	58.82
Mammoth Russian (Mam. Cluster), smut plots	2,345	457	19.49
Monarch, variety plots	2,102	198	9.42
New Red Rust Proof, smut plots	1,434	264	18.41
Race Horse, smut plots	4,051	1,627	40.16
§Race Horse, variety plots	1,449	498	34.37
Royal Doncaster, variety plots	1,459	76	5.21
Seizure, smut plots	3,774	332	8.80
Welcome, variety plots	1,473	112	7.60
§Welcome, variety plots	1,862	82	4.40
§White Belgian, variety plots	1,169	135	11.55
§White Bonanza, variety plots	1,223	68	5.56
§White Wonder, variety plots	1,039	59	5.68
Wideawake, variety plots	1,304	221	16.94
*Wideawake, Fertil. plots: no Fertilizer	1,193	239	11.65
*Wideawake, Fertil.: Dis. Bone Bl'k, Mur. Potash	1,344	194	14.43
*Wideawake, Fertil.: Dis. Bone Bl'k, Nit. Sod., Mur. Pot.	1,634	199	12.12
*Wideawake, Fertil. plots: no Fertilizer	1,126	203	18.02
†Wideawake, Fertil. plots: no Fertilizer	1,125	209	18.58
†Wideawake, Fertil.: Dis. B. Bl'k, Dried Blood, Mur. Pot.	492	105	21.30
†Wideawake, Fertil.: Dis B. Bl'k., Sulp. Am., Mur. Pot.	1,375	214	15.56
†Wideawake, Fertil. plots: no Fertilizer	1,391	237	17.04
‡Wideawake, Continuous Oats plots: Barnyard Man	1,161	219	18.86
‡Wideawake, Cont. Oats plots: no Fertilizer	1,062	261	24.57
‡Wideawake, Cont. Oats plots: Dis'd Bone Bl'k, Nitrate Soda, Mur. Potash	1,061	190	17.90
Totals and average per cent	68,724	13,824	20.12

§ Counts made by the Agricultural Department.

*, † ‡ and are series of adjacent plots.

For a portion of the counts above given, this department is under obligations to the Agricultural Department of this Station. In nearly all cases, except smut plots, the counts were made by measuring off 10 feet on each of eight drill rows and counting total stalks and smutted stalks in each row.

It is evident from the above results—an average of 20.12 per cent. smut, compared with those which follow less than 3 per cent.—that the oats at the Station have become worse affected with smut than the average in the State. This may, it seems, be properly attributed to growing varieties, including many susceptible ones, continuously from the same seed; a procedure rendered necessary by the conditions of variety experiments. Obviously the remedy is the treatment of all seed, which, I am informed, is to be the plan for 1896.

In addition to the results at the Station, determinations of the amount of smut in their several neighborhoods, were made by the following gentlemen to whom my obligations are gratefully acknowledged: Mr. John Begg, Columbus Grove, Putnam county; Mr. L. L. Bogue, East Orwell, Ashtabula county; Mr. Nelson Cox, Ensee, Lawrence county; Mr. F. M. Selby, Bartlett, Washington county; Mr. W. H. Todd, Vermillion, Erie county; and Mr. G. W. Breinzer, Canaan, Wayne county. The results are in part estimates or based upon limited counts; the latter are given where they throw light upon the percentages. These counts are given in Table II:

TABLE II.—SMUT COUNTS IN DIFFERENT PARTS OF OHIO, 1895.

Variety and other conditions.	Total stalks counted.	Number smutted	Per cent. of smut.
Reported by Mr Begg (Allen County):			
White oats	45	1	2.2
White oats, sown last of March			2.0
Scottish Chief, sown first of April			0.5
White oats, sown on wheat stubble April 13	40	3 to 7	12.5
Variety not known, sown last of March, on clover sod			0.5
Golden, sown April 5, on wheat ground			1.5 to 2.0
Reported by Mr. Bogue (Ashtabula County):			
White Russian, unphosphated sown April 25	454	46	10.13
" " phosphated, April 25	490	31	6.33
" " phosphated, corn stubble April 25	445	16	3.60
Nelson Cox, Lawrence County, says:			
"Not a single head of smut seen in oats this year."			
Reported by Mr. Selby (Athens County):			
Seizure, sown April 12	649	21	3.24
Golden Giant, sown April 10	627	7	1.12
Banner, sown April 12	621	11	1.77
Japan, sown April 4	514	5	0.97
White Swiss, sown April 4	527	3	0.57
Mr Breinzer reports			0.15
Mr. Todd (Erie County) reports:			
Race Horse and Badger Queen mixed	2,000	40	2.00
Totals	6,412	186	2.90

The counts at the Station show 20 per cent. of smutted stalks, therefore a loss of 20 per cent. in the crop, or, to put it another way, the crop harvested is 80 per cent. of what would have been the result under other like conditions, if the seed had been so treated as to prevent all smut. As will be seen from the results of treatment, this season, the treatment will do more than prevent the loss of smut; it will increase the yield beyond replacing this smut loss. Other localities from which estimates or counts were obtained, give an average of 3 per cent. of smutted heads, and a loss of like amount. Which result, if either, represents an average for the State, it would not be easy to determine, unless more extended counts were made. Estimates may mislead, since, upon actual count, the per cent. of smut is nearly always found to be higher than estimated. The observations made the present season, lead me to a higher estimate of the per cent. of smut than given by the various reports outside the Station. I am convinced that 6 per cent. represents the amount for the whole State very closely, and is more likely to fall below than rise above the general loss.

The average oat crop in Ohio for 1890 to 1894 is 25,168,000 bushels, with an average value of 30 cents per bushel, giving a total of $7,550,000 annually. The estimated yield for 1895,[21] is in round numbers, 32,000,000 bushels, having a value of $8,000,000. Six per cent. on this amount gives a loss of $480,000. A sum certainly worthy of recovery.

Quoting from a recent article by W. T. Swingle,[22] who has given much study to grain smuts: "It is undoubtedly a conservative estimate to place the direct loss from oat smut at 8 per cent. of the crop. Even at this estimate the loss in the United States is over $18,000,000 annually, averaging $18,504,140 for the years 1890 to 1893."

BOTANICAL CHARACTERS OF THE FUNGUS AND MANNER OF INFECTION.

We have already given the botanical name of the oat smut fungus, *Ustilago Avenæ* (Pers) Jens.; the variety of hidden smut has been noted to have smooth spores,[23] and was named *Ustilago Avenæ levis* (Pers) Kell. & Swing.[24]

This fungus and its variety belong to the order USTILAGINEÆ, THE SMUTS, which includes the smuts of barley, wheat, millet, corn and others. These diseases are all of them destructive, and particularly of the seeds and seed producing parts of the infected plants. Other parts are affected in some cases. In common with all smut fungi, *Ustilago Avenæ* is a parasitic plant, whose threads, *mycelium*, grow in the tissue of the host plant, sending specialized branches into the cells. Those branches of the mycelium which bear or produce spores at their tips, tend to become gelatinous and to disappear. This renders it difficult to find the branches after the spores approach maturity. The spores are produced in large numbers, constituting the dark masses which we find in place of the kernels and glumes, or destroying the kernels enclosed in apparently healthy glumes. For purposes of ordinary examination, the spores suffice. They are the bodies which reproduce the fungus, serving the same purpose as seeds in higher plants. Truly among the smuts we can say, 'without the spores no smut in grain.' The spores are minute, dark, mostly oval bodies, measuring 6 to 9x5 to 7 micromillimeters, approximately 1-3200 of an inch in longer diameter. In the ordinary form these spores are minutely spiny or warty, but smooth in the variety called *levis.*

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[21] From estimates of the State Board of Agriculture October 1, 1895, kindly supplied by Secretary Miller.

[22] Causes and Prevention of Grain Smuts, Year Book, U. S. Dep. Agric., 1894, p. 413.

[23] Kellerman and Swingle, Bul. 15, Kans. Exp. Sta., 1891, p. 101. See also Swingle, loc. cit., p. 412 note.

[24] Kellerman and Swingle, 2d An. Rpt. Kansas Exp. Sta., 1889, p. 259.

NOTE.—The earliest distinct description of hidden smut in oats that has come under the writer's notice is in The Cultivator (Albany, N. Y.,), Vol. IV, 3 S. 1856, p. 139:

> "......So general was this disease spread over this portion of country, and so unexpectedly, too, was it to our farmers, that no little surprise has been manifested. The crop grew luxuriantly, and promised to be as fine as we ever had (and it was heavy strawed), but after earing, the destructive ravages of the disease above mentioned made itself apparent. In many fields one-fourth, and in some one-third of the ears were entirely worthless. *It is different from what is called "blasted oats," the grain having the proper form but filled with a black dusty substance,* which is offensive to smell, and renders it unfit for food, especially for the horse, when cut with the straw cutter;....."
>
> (Italics mine.) "A PLOWMAN, *Canton, Ind.*"

Placed in a suitable nutrient solution, or less satisfactorily in distilled water, the spores will germinate in a thoroughly characteristic manner. This character is described by the works on fungi. It is to the spores which have found their way into the groove or opening of the husk that infection is attributed by Jensen.[25] Lodged there or adhering to the moistened seeds,[26] the spores are quickened by the same conditions that induce the germination of the seed oats. The, usually single, germ tube or thread, sent out by the germinating spore, finds entrance into the seedling oat plant only through the first sheath leaf, while the plant is very young and delicate. If infection does not take place at this early stage it cannot occur.[27] Some discussion has arisen as to the effect of barnyard manure upon propagation of oat smut. The results of experiments made upon this subject seem to indicate that the infection occurs by means of the spores adhering to the seed. The most conspicuous evidence adduced is that brief immersion of the seed in hot water, or longer in other media, is enough to prevent the smut. This seed immersion, manifestly, can have effect only on those spores adhering to the seeds, and none whatever upon any that might be in the manure. But the mistake of applying this argument to corn smut, upon which seed treatment has no effect, as shown by experiments by this department in 1895, should be avoided. Brefeld[28] and von Tubeuf,[29] have both shown that the effect of barnyard manure is to propagate corn smut. We are learning the necessity of distinguishing these heretofore confused life histories of the smuts of our common cereals.

But to return to the smut fungus which has penetrated the young tissues of a seedling oat plant: It continues to grow within the developing plant, the mycelial threads, branching, send sucking or feeding branches, *haustoria,* into the cells of the host. Other branches of the mycelium reach the inflorescence, and there, at the proper time, produce the spores of the fungus. Unless the fungus reaches the growing points, it fails to produce smut in the plant.

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[25] Loc. cit., p. 404.

[26] In this connection, consult Kellerman and Swingle, loc. cit., p. 236.

[27] Brefeld, loc. cit., p. 1590. Also Jour. Myc., Vol. VI, pp. 67-71.

[28] Brefeld, loc. cit, p. 1591. The same influence is claimed for oats and barley.

[29] von Tubeuf, Pflanzenkrankheiten, 1895, p. 295.

Brefeld[80] has, moreover, shown that while the germ tubes of any smut may penetrate other seedlings than those of its host, this penetration does not produce the disease in the foreign host. A point of value comes here, with respect to the presence of spores of other smuts among the seeds of any grain. These smut spores may grow but do not cause disease, except upon the host peculiar to them. Oat smut will not give rise to either sort of wheat smut, nor the reverse; nor can corn smut give rise to any of those mentioned except corn smut. While the fungus parasite has from a very early stage been growing within the affected oat plant, spore production is to us, the first manifestation, in gross. That the effect appears as if unannounced, led to the old view of some physical defect in development due to inorganic agencies working upon the grain plants. The evidence before adduced and that which follows in results of treatment, seem more than enough to prove the present doctrine; this leaves out of consideration the direct evidence, always the most valuable, furnished by microscopic examination of the fungus in the host plant.

LIFE HISTORY OF OAT SMUT FUNGUS.

The beginning of the life cycle, as of the smut infection of the oat, is in the spore or spores previously produced and having lodgment upon or within the oat husk. The spores so adhering may be distributed by the wind, at or subsequent to blossoming, or become attached in threshing. It is believed that the former method is most usual with oat smut. With the oat husk intact, those spores which are within the husk or the opening of the husk, are, by their germination, most capable of causing infection. The infection results from the growth of the spore by sending out a germ tube which enters the young seedling exclusively while the seedling is very small, and, moreover, only by penetration of the germ tube through the first sheath leaf, and thus into the plant tissues. When the leaves of the seedling have protruded a short distance beyond the sheath, the germ tubes can no longer penetrate and infection cannot occur. The germ tubes which find entrance into the oat plant by penetration as above, continue to grow, developing a mycelium within the growing or dormant plant, branching and feeding upon the host internally. Finally, as the host plant approaches seed bearing, the mycelium produces spores within the seed organs which its branches have penetrated. These spores are scattered by the agencies before contemplated. The length of time during which the smut spores remain capable of germination is probably as long as seed is often kept. Spores of *Ustilago Carbo* have been germinated after preservation in the herbarium for 7½ years.[31] Brefeld[32] observes that while barley dusty smut spores would not germinate after 1 year, those of oat smut still germinated readily after more than 6 years.

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[80] Loc. cit., p. 1592.

SPREAD OF SMUT IN FIELDS—EFFECT OF CHANGE OF LOCATION.

Some observed facts of spread of smut in fields are reserved for discussion at this time. As is stated of their results by Kellerman and Swingle,[33] artificial smutting, by dusting spores upon oats in blossom, did not give any decided results the second year, and would therefore not be expected to do so the first season. Four small plots of Seizure oats were chosen for dusting this season. One plot dusted with smut from 1894, gave 12.08 per cent.; one dusted upon same dates with spores of 1895 gave 8.84 per cent.; while the two not dusted and adjacent, showed 10.94 and 10.64 per cent. of smut, respectively. In each case about 2,500 stalks were counted. The result is, at this stage, of no importance. The dusting was repeated twice during blossoming.

But oats grown in proximity to smutted varieties certainly tends to become smutted. A table from Bulletin 57 of this Station[34] gives results for certain varieties 1891 to 1894, inclusive, and certain ones for 1894 only. The data there given are reproduced in Table III, to show results of 1895 in comparison:

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[31] Zopf, Die Pilze, p. 218, quotes Liebenberg, Unters. ü. d. Keimung d. Pilzsporen Pringh., Jahrb. II, p. 334 The source of the spores and whether from oats is not stated.

[32] Loc. cit., No. 221, p. 1593 note. Also Jour. Myc. VI, p. 155.

[33] Loc. cit., p. 236.

[34] Hickman, J. Fremont. loc. cit., p. 114.

TABLE III.—SMUT COUNTS IN OATS FOR SEVERAL YEARS.

Percentage of Smutted Panicles.

Variety.	Ohio Station.					Vermont Station.
	1891.	1892.	1893.	1894.	1895.	1895.
Black Prolific	3.2	2.8	13.3	34.0	31.0	29.4
American Banner	7.3	4.5	9.7	13.9	34.6	37.7
Race Horse	5.7	3.9	8.4	19.1	40.2	49.7
Lincoln	6.4	6.0	12.0	29.0	58.8	....
Mammoth Russian	....	....	....	5.9	19.5	....
Wideawake	....	....	....	2.6	16.9	....
Welcome	....	....	....	1.7	6.0	....
White Wonder	....	....	....	*	5.9	....
Seizure	....	....	....	*	8.8	....
Black Norway	....	....	....	....	45.2	31.2

* Less than 1%.

For the results of the Vermont Station we are indebted to Prof. L. R. Jones, Botanist of that Station.

The seed sown here and in Vermont was supplied by this Station, and taken from the same package after careful mixing of the whole contents. In the results for successive years the crop of the previous year was taken for sowing for the subsequent one.

Three varieties grown here among the badly smutted plots from seed the same as that supplied Mr. F. M. Selby, of Bartlett, gave the following results:

	Per cent. of smut at Station.	Per cent. of smut at Mr. Selby's.
Japan	2.49	0.97
White Swiss	5.59	0.57
Seizure	8.80	3.24

The counts are certainly very interesting. The difference in treatment was in soil and location, and in the application of fertilizers, which were sown with the oats on Mr. Selby's ground, with fertilizer drill. The fertilized plots given in connection with Wideawake, p. 120, received the same treatment. The oats here were sown April 22, and those at Bartlett, April 4, for Japan and White Swiss, and April 12 for Seizure.

METHODS OF PREVENTION.

The successful methods of prevention for oat smut are now at least two in number, hot water at 130° to 135° F. by the method of Jensen,[35] and potassium sulphid (liver of sulphur) solution by the method of Kellerman and Swingle.[36] Either of these methods is thoroughly effective, and the matter of choice between them is likely to depend somewhat upon the taste or appliances of the user. The method of Jensen, a dipping process, requires more careful regulation and the use of an accurate thermometer, but has the advantages of cheapness, cleanness in manipulation, and diminished difficulty in drying the treated seed. The method of Kellerman and Swingle is a soaking process, of which the great advantage is that no thermometer is required, and, perhaps, less careful attention during treatment. But in either case there is an abundant return for special care and attention. The potassium sulphid, for the solution, must of necessity be weighed and directions followed for best results. The disadvantages of its use are the great difficulty in drying the treated seed, with corresponding trouble in sowing with the drill. Long soaking has, moreover, a disorganizing effect upon the seeds. The experiments, of which results are given, show the efficacy of both methods.

Aside from the methods of prevention now in use, there are others having a historical interest, and what is stated here concerning them is solely from this point of view. In the American Farmer of September 29, 1820, p. 215, a correspondent tells of oats so badly smutted that "the cradlers were nearly as black as colliers." This oats lay upon the ground for curing, in the old manner, and was turned after showers some four or five times, before binding and gathering. The same oats sowed the next season gave a crop free from smut (blast). This case shows the possible mechanical effect of washing. The process as one for practice would certainly prove expensive. In the Cultivator, May, 1856, p. 139, an Indiana correspondent, upon reporting much smut of oats in Southern Indiana, inquires the cause of oat smut and if there is a preventive known; also, whether the disease will continue to increase until it destroys the whole crop. The editor in comment states:

> "Smut in oats is common in some countries, but we have never witnessed it as a serious evil. Like the smut of wheat, which is more generally known, it is a parasitic

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[35] Loc. cit., p. 413.

[36] Bul. 15 Kans. Exp. Sta., 1890, p. 129.

fungus growing in the grain, totally disorganizing it, and destroying its substance. Doubtless the same *preventive* remedy as is commonly used for the seed of wheat, would prove equally efficacious with oats, namely: Washing the grain thoroughly in water, or still better in brine (or giving the last washing in brine), and then rolling it well in dry, powdered, water-slaked, fresh lime, some hours before sowing. If the crop is now sown on clean, fresh land, the probability is that little smut will be seen in the future crop."

A quotation from the Cultivator in Farmer's Cabinet, 1837, vol. II, 107, states the method as "steeping the seed grain twelve hours in brine and rolling it in fresh slaked lime before sowing." We are to infer, I take it, that the method of brining and liming was prevalent between 1837 and 1856 where any preventive was applied.

Washing and then brining, combines both the mechanical and chemical procedures. Washing before treating is still recommended for the stinking smut of wheat, but is entirely unnecessary with oat smut. Copper sulphate (blue vitriol) solution has been used for oat smut by many experimenters. The results are generally less satisfactory, both as to prevention of smut and increase of yield, than the Jensen or the Kellerman-Swingle treatment.

Jensen published his success with hot water treatment for smut in 1887 and 1888. Kellerman and Swingle published the results of potassium sulphid treatment in 1890. In 1895, Jensen[37] appears as the advocate of a preparation for seed treatment. This preparation, called Ceres powder (Ceres-pulver), is for sale by the disseminators, but has as yet been given no trial at this Station. Trial is contemplated next season. As will be seen from the title of the pamphlet, which lies before me, the "Ceres-pulver" is claimed to prevent the smuts of oats and barley and the root disease of mangold and sugar beets, and to increase the yield. The last claim immediately starts speculation as to the composition of this powder. Certainly there is no need to rely upon as yet unknown powders, whatever the name, when we have two such successful methods as those which follow, both of them increasing the yield.

METHODS OF TREATMENT RECOMMENDED.

The methods used for oats at this Station and recommended for prevention of smut and increase of yield are the Jensen hot water treatment and the Kellerman-Swingle potassium sulphid treatment. Attention has been confined to these because they seemed well established as to results, and the primary object of the whole investigation and of this publication, is to spread the use of well established methods of seed treatment among the grain growers of the State. The discussion and experiments have been limited to oat smut, but the hot water treatment appears to be applicable to the smuts of barley[38], if the grain is first soaked in water four hours and then allowed to stand four hours in wet sacks before treatment. It is then dipped, for five minutes only, in water at a temperature of 130° F.[39] The hot water method as herein described, is applicable to the treatment of wheat for stinking smut[40] without modification, except that 10 minutes is sufficient for immersion in hot water, at 133° F., and the grain should be previously immersed in cold water and skimmed. The principle is the same in all cases, namely: The destruction of adhering spores of smut without injuring the germinating power of the seed grain. (In case of barley there will be some injury to seed.) Moreover, the results of seed treatment have been found favorable to the germination of the treated seed, increasing its germinating power by hastening the development of the seedling. Seed treatment is apparently to be recommended even in cases where no smut occurs.

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[37] Neue Methoden um den Brand in Hafer und Gerste und den Wurzelbrand in Zucker- und Runkel-Rüben zu beseitigen und die Ernte zu vermehren etc., Deutsche Ceres, J. L. Jensen & Co., Halle a. S., im Februar, 1895. Also in Zeitschrift für Pflanzenkrankheiten, V. Band, 1895, pp. 187-190.

HOT WATER TREATMENT.

The hot water treatment given below, is essentially the same as given by the writers upon smut prevention; the details are those actually employed. This method consists in immersing the seed oats, previously raised in temperature, for 15 minutes in hot water at a temperature of 133° F. and then drying for sowing. The immersion destroys adhering smut spores without injury to the seed grain.

The vessels and apparatus required are:

1. A coarse, open gunny sack or wire mesh basket, of capacity of 1 to 2 bushels, with cover of same sort (12 meshes to the inch), to hold the grain during treatment. A perforated tin vessel is also excellent. It should not be more than one-half to two-thirds full of grain.

2. A well graduated thermometer, of Fahrenheit scale; the small floating dairy thermometer, for sale nearly everywhere at 25 cents, is the one used here; the large dairy thermometer is a good instrument. The small thermometer is not graduated above 160°, and will be ruined if thrust into boiling water for any length of time. There is little danger of breaking the thermometer, except through knocks or falls.

3.. Two vessels of, preferably, 25 to 50 gallons capacity, to contain hot water, or in which the water is heated. In the first of these the water is kept at 120° to 125° F.; it is for warming the grain preparatory to immersion in the second vessel. In the second vessel, which is for the actual seed treatment, the water is maintained at a temperature of 133° F. Where two kettles are used in which to heat the water, the grain may be dipped or immersed directly in them. Where a threshing boiler or steam from a boiler is used as a source of heat, deep tubs or 50-gallon barrels with one head removed, make satisfactory receptacles. In addition, a bucket of cold water and some ready source of hot water will be required.

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[38] *Ustilago hordei* (Pers.) Kell. and Swing., and *Ustilago nuda* (Jens.) Kell. and Swing.

[39] Swingle, W. T., loc. cit., p. 417.

[40] *Tilletia tritici* (Bjerk.) Winter, and *Tilletia fœtens* (B. & C.) Schroeter.

4. The heating of the water may be accomplished by fires or by steam from boiler as above indicated. In the case of kettles, a small fire may be kept continuously under the second one.

5. A suitable floor or canvas upon which to dry the grain after treatment.

The two vessels, of ample capacity, should hold several times—8 to 10 times—the volume of seed grain to be immersed at any one time. Having these, they are filled with the hot water and the temperature is determined by the thermometer; the first, with water at 120° to 125° F., is for dipping the seed in order to warm it and to prevent too great fall of temperature in the second vessel; the second, with hot water at 133° F., is for the actual immersion of seed. The basket or sack containing the seed is dipped into the first vessel, with twirling; after a moment it is lifted and again dipped several times; when thoroughly warmed (less than a minute usually suffices for dipping into the first vessel) it is withdrawn and directly plunged into the second vessel, which has the water at 133° F. Here it is kept, with lifting and plunging many times (8 to 10), and with stirring the contents, by twirling, handling or otherwise, to secure thorough contact of all the grain with the hot water. This lifting and plunging and stirring of contents is very necessary to destroy all smut. The thermometer must be in constant use in this second vessel; if the temperature tends to fall, more hot water is added or steam is introduced. If the temperature rises too high above 133° F., cold water may be added. In all cases, after addition of hot or cold water, the water needs to be stirred to secure uniform heat, and in no case should very hot water be poured upon the grain being treated. The whole operation of immersion must be carefully conducted to insure success. At the end of 15 minutes the seed is withdrawn and, after draining, spread at once for drying. If not to be spread at once, the treated seed should be cooled with cold water immediately upon withdrawal. The treated grain is spread upon canvas or a clean floor free from smut spores, and dried with frequent stirring. It need not be completely dry before sowing, but if much moist.

great difficulty in drilling will result, especially in the matter of equal distribution of seed.

If large quantities of seed are to be treated, the amount treated at one time should not be too greatly increased, but appliances for lifting, handling and maintaining proper temperature may be readily devised. One of these suggested is a pole with hook to attach to treating vessel. This pole needs to be fixed at one end and should be capable of support at various heights at the other. The two barrels may be so situated as to be within the radius of the swing of the pole. A good suggestion in this line by Swingle, will be found in the U. S. Department of Agriculture's Year Book, 1894, p. 416.

PRECAUTIONS.

The needful precautions in the hot water method are:

1. Maintain the proper temperature of the water in the second vessel at 133° F., not permitting it to go above 135° nor to fall below 130° F. Too high a temperature will injure the grain, and too low will fail to destroy the smut.
2. See that the volume of scalding water is several times that of the seed treated at any one time.
3. Never fill the sack or basket containing the seed entirely full, as there must be room for movement of grain to secure uniform contact with the water.
4. Leave the seed in the second vessel 15 minutes.

POTASSIUM SULPHID TREATMENT.

This method relies upon the chemical effect of potassium sulphid as a fungicide, and is based upon spore destruction without grain injury, as is the other. The potassium sulphid (liver of sulphur) may be obtained in fused cakes at nearly all drug stores, the price varying from 25 to 40 cents per pound, according to quantity purchased. It should be kept tightly closed in a bottle. This salt is very readily soluble in water and makes a strongly alkaline, soapy solution, of yellowish or brown color.

NOTE. Seed treatment by seedsmen or large dealers is worthy careful calculation. One who treats thoroughly the seed oats or other grain offered for sale, ought to have no difficulty in realizing a good return upon the investment. The treatment may be made some weeks before the seed is wanted and if thoroughly dried no impairment of vitality will take place. The hot water method is the only one applicable on a large scale, without excessive care in drying the seed. For such a purpose, two large hogsheads, in which the water is heated from a steam pipe, will prove very satisfactory. The immersing vessel may be made of larger capacity, holding several bushels, and consisting of metal framework, covered with wire netting, 12 meshes to the inch; the lid to be of the same material. If this vessel is handled by means of a pole, as suggested by Swingle, the work will not be over heavy and treatment may proceed rapidly. In this way the cost of treatment may be reduced to a few cents per bushel, and an added price of 15 cents per bushel might be realized.

The materials and apparatus needed in this method are weighed quantities ($\frac{3}{4}$ or 1$\frac{1}{2}$ lbs.) of potassium sulphid, a suitable wooden vessel, as a barrel or a large tub, and a convenient drying place. Reserve quantities of cold water are also required.

Make a $\frac{3}{4}$ per cent. solution, by dissolving 1$\frac{1}{2}$ pounds of the fused potassium sulphid in 25 gallons of water contained in the wooden vessel. Stir the solution thoroughly; about three bushels of oats, if loose, or a smaller quantity in sack, may be treated at once. The solution should stand a few inches above the oats to be treated, so that the grain is completely covered. Stir the whole well to secure wetting of all the grain. The oats are left in the solution 24 hours (in the seed we treated, $\frac{1}{2}$ per cent solution, 18 hours, but better longer). Stir a few times during this period. The liquid may be poured off at the end of the time, and the grain should be washed with fresh water to facilitate subsequent drying. The solution can be used once or twice more, but should not be used oftener.

The precautions in the potassium sulphid treatment are:

1. Have enough liquid to cover grain several inches deep, as great swelling of the grain occurs.

2. Stir the solution well before adding the seed and also during the soaking.

3. Do not put the solution into a metal vessel, nor use the same solution more than two or three times.

4. Wash with water after treatment.

The great difficulty is in drying the seed, which is likely to be more or less sprouted and very much swollen. The Kansas recommendation is to sow before drying thoroughly, yet fairly good drying is necessary to successful seeding. Washing after soaking is a great aid in drying.

THE EXPERIMENTS OF 1895.

These experiments, with Jensen and Kellerman–Swingle methods of seed treatment, were conducted upon several varieties of oats, chiefly those with very high percentages of smut. In this respect factors were introduced into the experiment that, so far as I have observed, are not common to previous experiments in this line. Difficulties are also met which make any very sweeping statements impossible. It is the aim in the presentation here made to let the experiments speak for themselves.

The plots, 21 in all, including one which was not harvested separately, were of $\frac{1}{30}$ acre area, lying contiguously, except for a break between plots 16 and 17 as shown in the diagram of plots. This break was to escape a local variation in soil. The soil of the plots is a fairly uniform, light loam, of low fertility. The field was in ensilage corn in 1894

DIAGRAM OF OATS PLOTS AS TREATED FOR SMUT, 1895.

"A."	Race Horse, untreated. 41.62 per cent. smutted.
1.	Race Horse; hot water, 132.8° F., 15 minutes. 0.24 per cent. smutted.
2.	Race Horse, untreated. 39.47 per cent. smutted.
3.	Race Horse; potassium sulphid, ½% solution, 18 hours. 1.006 per cent. smutted.
4.	Black Prolific; hot water, 132.8° F., 15 minutes. 0.21 per cent. smutted.
5.	Black Prolific, untreated. 31.05 per cent. smutted.
6.	Black Prolific; potassium sulphid. ½% solutson, 18 hours. 0.21 per cent. smutted.
7.	Lincoln, untreated. 58.82 per cent. smutted.
8.	Lincoln; hot water, 132.8° F., 15 minutes. 2.21 per cent. smutted.
9.	American Banner, untreated. 34.56 per cent. smutted.
10.	American Banner; hot water, 132.8° F., 15 minutes. 2 per cent. smutted.
11.	Mammoth Russian, untreated. 19.49 per cent. smutted.
12.	Mammoth Russian; hot water, 132.8° F., 15 minutes. 0.51 per cent. smutted.
13.	New Red Rust Proof, untreated. 18.41 per cent. smutted.
14.	New Red Rust Proof; hot water, 132.8° F., 15 minutes. 0.24 per cent. smutted.
15.	Black Norway, untreated. 45.21 per cent. smutted.
16.	Black Norway; hot water, 132.8° F., 15 minutes. 1.03 per cent. smutted.

17.	Seizure, untreated. 7.29 per cent smutted.
18.	Seizure; hot water, 132.8° F., 15 minutes. 0.45 per cent. smutted.
19.	Seizure, untreated. 10.40 per cent. smutted.
20.	Seizure; potassium sulphid; ½% solution, 18 hours. 0.11 per cent. smutted.

and had been manured with stable manure the previous winter. No fertilizer was applied in 1895. The drainage of the soil is good, sloping very slightly to the north, and soil conditions were fairly good, the earth having been moist and mellow at the time of seeding. For the preparation of the soil, sowing and harvesting this department is under obligations to the Agricultural department of this Station. The seed, treated two days previously, was well dried and sown with drill at the rate of seven pecks per acre, April 22, 1895. As before stated, the seed was in many cases from plots having a high percentage of smut in 1894, and in all cases except two, the per cent. of smut had been determined in that season. There were imperfections of seed treatment, such as filling sacks too full, using too low vessels to contain the hot water, and consequent difficulties in stirring the grain well during treatment.

The following were the percentages of smut in 1894, in the plots from which seed was obtained and the per cent. of smut in untreated plots in 1895:

	1894.	1895.
Race Horse	19.1 per cent.	40.16 per cent.
Black Prolific	34 0 "	31.05 "
Lincoln	29.0 "	58.82 "
American Banner	Not known.	34.56 "
Mammoth Russian (cluster)	5.9 per cent.	19.49 "
New Red Rust Proof	Not known, high.	18.41 "
Black Norway	" "	45.21 "
Seizure	Less than 1%.	8.80 "

This shows a large amount of smut to deal with and the results indicate varietial differences or other undetermined factors. The table gives variety of oats, treatment of seed, smut results, yield of straw, yield of grain, and effect of treatment on yield, both in respect to increase per acre and to the replacement of smutted panicles.

The counting was done, in nearly all cases, by measuring off at a fixed point, 10 feet on each of 8 rows, and counting total stalks and number of smutted panicles. In addition to this area, two others were measured off, 4 feet on each of 8 rows and the counts similarly made. The four-foot areas were selected to represent average conditions. The table shows total areas counted in each case.

TABLE IV.—Results of Treatment of Oats for Smut.

Plot.	Variety.	Treatment of seed.	Smut results.				Yield of straw.		Yield of grain.		Effect of treatment (per acre).			Plot.
			Total heads counted.	Area counted.	Number heads smutted.	Per cent. smutted heads.	Weight per plot.	Weight per acre.	Yield per plot.	Yield per acre.	Increase over untreated.	Calculated amount to replace smutted heads.	Net increase aside from smut prevention.	
							Pounds.	*Pounds.*	*Pounds.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	
"A"	Race Horse	Untreated	1,307	5′ 4″x8′	544	41.62	*	....	....	....	....	....	....	"A"
1	"	Hot water	2,465	5′ 4″x18′	6	0.24	54 25	1,627	60.75	56.95	25.07	0.14	3.47	1
2	"	Untreated	2,744	5′ 4″x18′	1,083	39.47	61.00	1,830	34.00	31 88	....	21.74	....	2
3	"	Potas. sulphid	2,432	5′ 4″x18′	25	1.01	40 75	1,222	59.25	55.55	23 67	0.57	2 50	8
4	Black Prolific	Hot water	2,863	5′ 4″x18′	6	0.21	45.00	1,350	67.00	62.81	18 75	0.12	—0.97	4
5	"	Untreated	2,557	5′ 4″x18′	794	31.05	86.00	2,580	47.00	44.06	....	19 84	....	5
6	"	Potas. sulphid	2,314	5′ 4″x18′	5	0.21	69 00	2,070	76.00	71 25	27.19	0.15	7.50	6
7	Lincoln	Untreated	3,033	5′ 4″x17½′	1,784	58.82	69.50	2,085	30.50	28 60	....	40.85	....	7
8	"	Hot water	2,619	5′ 4″x18′	58	2.21	51.75	1,552	73.25	68 67	40.07	1 55	0.77	8
9	American Banner	Untreated	2,633	5′ 4″x18′	910	34.56	79.50	2,385	45.50	42.66	....	22.53	....	9
10	" "	Hot water	2,792	5′ 4″x18′	56	2.00	58.50	1,755	71.50	67.03	21.37	1.37	3.21	10
11	Mammoth Russian	Untreated	2,345	5′ 4″x18′	457	19.49	65 00	1,950	50.00	46.88	....	11.35	....	11
12	" "	Hot water	2,131	5′ 4″x18′	11	0.51	51.50	1,545	68.50	64.22	17.34	0.33	6.32	12
13	New Red Rust Proof	Untreated	1,434	5′ 4″x8′	264	18.11	47 50	1,425	47.50	44.53	....	10.05	....	13
14	" "	Hot water	2,994	5′ 4″x18′	7	0.24	43.75	1,312	56.25	52.73	8.20	0.13	—1.72	14
15	Black Norway	Untreated	1,935	5′ 4″x18′	902	45.21	49 50	1,485	35.50	33 28	....	27.46	....	15
16	"	Hot water	2,228	5′ 4″x18′	23	1.03	57.00	1,710	63.00	59.06	25.78	0.51	—1.17	16
17	Seizure	Untreated	1,934	5′ 4″x18′	141	7.29	48 00	1,440	57.00	53.41	....	5.28	....	17
18	"	Hot water	1,748	5′ 4″x18′	8	0.45	69.50	2,085	65.50	61.41	7.03	0.15	3.07	18
19	"	Untreated	1,836	5′ 4″x18′	191	10 40	56.00	1,680	59.00	55.31	....	5.28	....	19
20	"	Potas. sulphid	1,800	5′ 4″x18′	2	0.11	57.00	1,710	68.00	63.75	9.37	0.15	3.07	20

* Not gathered separately.

TABLE V.—Summary of Table IV.

Plot	Treatment of seed.	Per cent. of smut.	Yield per acre.	Increase over untreated plots.	Net increase or decrease—aside from smut prevention.
			Bushels.	*Bus. per acre.*	*Bus. per acre.*
1	Hot water	0.24	56.95	25.07	3.47
2	Untreated	39.47	31.88		
3	Potas. sulphid	1.01	55.55	23.67	2.50
4	Hot water	0.21	62.81	18.75	—0.97
5	Untreated	31.05	44.06		
6	Potas. sulphid	0.21	71.25	27.19	7.50
7	Untreated	58.82	28.60		
8	Hot water	2.21	68.67	40.07	0.77
9	Untreated	34.56	42.66		
10	Hot water	2.00	67.03	24.37	3.21
11	Untreated	19.49	46.88		
12	Hot water	0.51	64.22	17.34	6.32
13	Untreated	18.41	44.53		
14	Hot water	0.24	52.73	8.20	—1.72
15	Untreated	45.21	33.28		
16	Hot water	1.03	59.06	25.78	—1.17
17	Untreated	7.29	53.44		
18	Hot water	0.45	61.41	*7.03	+3.07
19	Untreated	10.40	55.31		
20	Potas. sulphid	0.11	63.75	*9.37	†3.07

* Average, 8.20. † Average. Net increase, 2.37 bushels.

If this series of experiments gave results quite at variance with those previously obtained elsewhere, we could scarcely claim that much is shown by them. But yielding, as they do, confirmation of previous results with oats containing like percentages of smut, they add their modicum to the proof upon this subject. The variation in amount of smut in the different treated plots may be attributed, I believe, to the imperfect stirring of the seed during treatment. The necessity of this agitation should be emphasized. Sacks were used for immersing the seed, and for the reason that gunny sacks are more readily secured than wire mesh or other baskets.

From the foregoing summary of results it is observed, that treated plots of Race Horse, Black Prolific, Mammoth Cluster, Seizure and American Banner gave a net increase, beyond smut prevented, amounting to 3 bushels or more per acre. Two varieties failed to give a net increase beyond smut prevented, although giving increased yields of 8.2 to 25.8 bushels per acre over the untreated plots. The average of all is a net increase of 2 37 bushels per acre.

Upon the plots of seizure, 17 to 20 inclusive, wherein the amount of smut in untreated plots was 8.85 per cent., a proportion much nearer the average in the State, we can, I believe, base some conclusions of value. These treated plots give an *average increase in yield of* 8.2 *bushels per acre and a net increase of* 3.07 *bushels per acre over the average of the two adjacent untreated plots.* In other words, this and the average of all as well, indicates a net increase in yield per acre which more than covers the cost of seed treatment; the amount of increase (*in this case* 5.28 *bushels per acre*) due to smut prevention being the net profit. Applied to the estimated loss of $480,000 in the whole State, these results show a large saving. Further comment seems wholly unnecessary.

SUMMARY.

1. Smut in oats, a disease long known and generally regarded as unimportant, really causes large losses among growers.

2. The amount of smut varies. This was about 20 per cent. of the whole at the Station in 1895, and 6 per cent. appears to be a conservative estimate of the smut in the State.

3. The losses caused by smut therefore amount to $480,000 annually in Ohio, and more than $18,000,000 per year for the United States.

4. Oat smut is due to a parasitic fungus, *Ustilago Avenæ*, or its variety *levis*, whose spores adhere to the seed grain and germinate with the seed; the mycelium enters within the seedling, finally reaches the grain bearing parts and destroys them.

5. The smut is prevented by the destruction of all these attached spores, which is possible by seed treatment, without injury to the grain.

6. Immersing the seed oats for 15 minutes in hot water at a temperature of 133° F. not only destroys the smut but increases the yield beyond mere smut prevention.

7. Soaking the seed for 24 hours in a $\frac{3}{4}$ per cent. solution of potassium sulphid, made by dissolving $1\frac{1}{2}$ pounds of the salt in 25 gallons of water, is equally efficient in smut prevention.

8. The net increase in yield beyond smut prevention appears sufficient to defray cost of seed treatment.

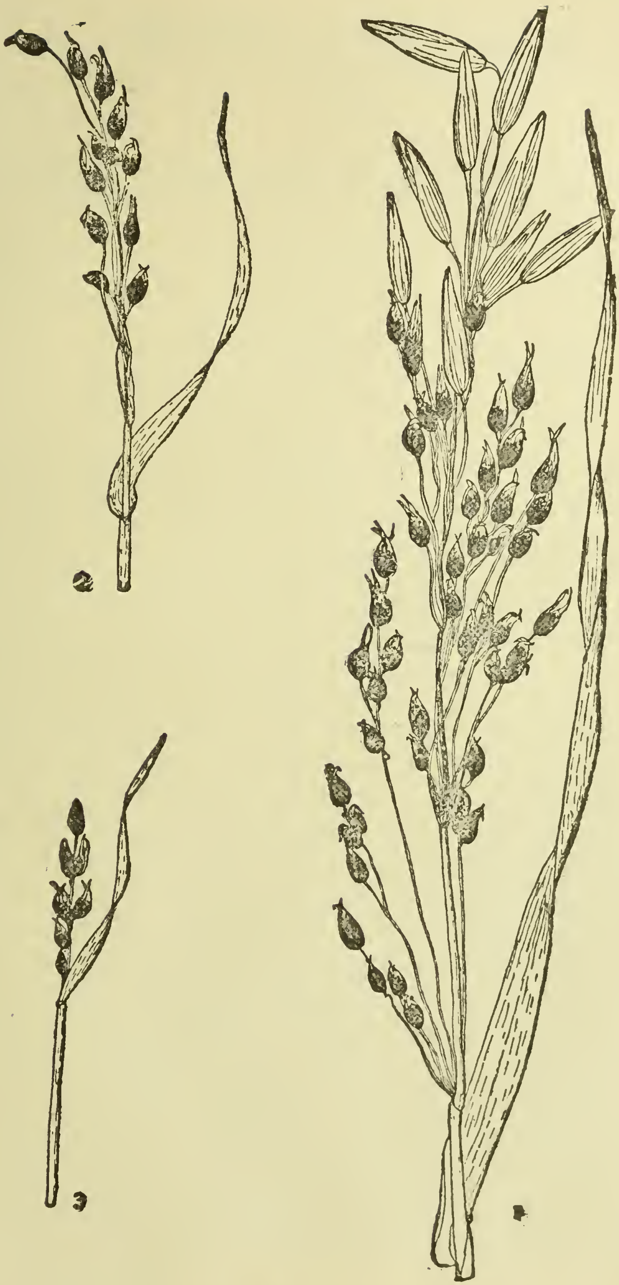
EXPLANATION OF PLATE.

Plate 1. Loose Smut of Oats, *Ustilago Avenæ* (Pers.).

Fig. 1. Head or panicle of oats, with all but the uppermost grains smutted.

Figs. 2 and 3. Small panicles, with all the grains smutted. All natural size. Cut obtained from Kansas Experiment Station.

PLATE I.



SMUT OF OATS.

BULLETIN

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VARIETY TRIALS OF POTATOES.

BY W. J. GREEN AND H. O. McFADDEN.

Since the removal of the Station from Columbus variety tests of potatoes have been carried on as before, but no report of the work done here has been made. In 1893 the trials were made on quite a small scale, but in 1894 and 1895 the plot areas were enlarged, and the work duplicated. The size of the plot is now the $\frac{1}{60}$ part of an acre, and each variety is planted in two different parts of the field, except such new sorts as are sent in for trial in quantities too small for duplication.

That this plan is more satisfactory than very small plots, without duplication, is now evident. Two sub-stations, one in Fulton county, on sandy soil, and the other in Cuyahoga county, on a very heavy clay soil, are now in operation, and the same work is carried on at these places. Just how much of general value there is in variety testing of potatoes is a question not easily answered. It is well known that any given variety may vary in yield in separate trials, and it is sometimes assumed that differences in soil are responsible for the greater part of these variations, hence it is declared that a test on one soil is no criterion of what a variety may do on another. The logical inference is that each one must learn for himself just what varieties are suited to his soil, as the experience of others is worth nothing to him. Any one who undertakes to make a careful test of any list of varieties of potatoes will find that duplicate trials on the same soil, in the same or consecutive seasons, will not agree in placing the varieties in the same consecutive order in yield. We have found almost as great a variation in varieties in one field as on different classes of soil. This shows that there are other causes of variations besides differences of soil.

One hill may yield double the quantity of another hill alongside. It is not necessary to discuss these causes of variation, but it is sufficient to say that they are numerous and complicated, and that it is impossible to separate them, so as to show the proportional effect of each. This makes it appear as though it were impossible for a variety test of potatoes to have either general or local value. That is, no one can find out to a certainty what variety is best adapted to his soil, if the result of one trial contradicts that of another. This conclusion seems absurd, for different growers do, in some manner, find out which are the best varieties.

This reasoning leads to a false conclusion because it unduly magnifies certain facts and ignores others.

The effect of different classes of soil in causing variation is overrated; the inherent tendency of varieties to vary is not considered at all; nor is the fact that all varieties are not alike in degree of variability.

Some varieties are almost invariably at the head of the list in yield, while others are as constantly at the foot. In our trials the Early Ohio has never, in any soil or season, risen to the head of the list in yield, nor even up to the average, while the reverse is true of the American Wonder. With these might be grouped many other varieties which have invariably kept a place either near the head or the foot of the list. There are others which have pretty constantly held an intermediate place, while there are still others that have fluctuated so widely as to defy grouping.

A variety trial must be looked upon as an item of evidence concerning each variety under consideration. A great many such items, from different sources, must be accumulated before a conclusion can be reached, and it is an undeniable fact that one can reach a conclusion more quickly by comparing the results of others with his own than by working alone.

This report is offered as evidence regarding the behavior of varieties here and at the sub-stations. It gives evidence that certain varieties are much more prolific than others; that some are more susceptible to blight than others, at least that some resist the disease a longer time than others; that certain varieties bear so close a resemblance to others as to be indistinguishable; that many claims of seedmen regarding the varieties offered cannot be substantiated, besides items on other minor points.

Any one who takes this evidence as conclusive may make a mistake, just as he might if he were to draw conclusions from one season's trial of his own. On the other hand, this evidence may be useful to any one who puts it alongside of his own experience, and it may be helpful to any one without experience, in serving to direct attention to certain characteristics of varieties.

Any variety trial is useful in so far as it offers trustworthy evidence, and a combination of local results is sure to bring out some facts of general value. The general value of any single trial of varieties is very small, standing alone. It needs corroboration, before we can determine what it is worth. If the soil were the principal factor in causing variation, or if all varieties were fickle alike, there would be none adapted to large areas of country; but the fact that there are kinds which do well on different soils, and that these are the best locally, makes it an incentive to determine as quickly as possible to which class new sorts belong, whether to the fickle or reliable. The purpose of a variety trial here is not to determine this point, but to help to determine it. The results are suggestive merely, and ought not to be taken in any other way. The principal object in offering these remarks is that these results may be taken as suggestive and tentative, rather than as conclusive and final.

In Table I is given a list of varieties grown in 1895, with yields in bushels per acre:

TABLE I.—Comparison of Varieties of Potatoes.

Variety.	Yield per acre.	Variety.	Yield per acre.
American Wonder	276	Maggie Murphy	238
Acme	272	Maule's Thoroughbred	357
Algoma	209	New Queen	254
Banner	201	Nebula	266
Brownell's Winner	243	New Northern	268
Bovee	358	New Burbank	237
Carman No. 1	262	Onward	236
“ No. 3	224	Oregon Pearl	235
Columbus	281	Pennsylvania's Best	283
Clay Rose	214	Penn Manor	252
Craig	211	Peerless Jr	261
Early Rose	217	Parker's Market	228
“ Norther	270	Rural New Yorker No. 2	213
“ Cyclone	261	Somerset	248
“ Morn	281	Sir William	308
“ Oxford	294	Stoneroads No. 1	258
“ Harvest	290	“ No. 2	288
“ Pinkeye	270	Salzer's Prizetaker	154
“ Ohio	207	“ Earliest	177
“ Puritan	298	Shamrock	185
“ Everitt	274	Timpee's No. 4	223
Everitt's Six Weeks	202	Thorburn	242
Empire State	312	Vick's White Gem	159
Freeman	237	“ Early Pride	292
Forest Rose	304	“ “ Prize	282
Gov. Rusk	251	Victor Rose	244
Great Divide	215	Van Orman's Superb	236
Green Mountain	286	“ “ Earliest	249
Heavy Weight	240	“ “ No. 99	224
Harvest King	210	World's Fair	266
Irish Daisy	247	Wisconsin Beauty	269
Illinois Queen	229	Wolfgang	330
Koshkonong	309	Wood's Earliest	269
King of the Mammoths	330	Wise	323
King of the Earliest	200	Wilson's First Choice	232
Lightning Express	221		

The planting was done May 16, 17 and 19. The potatoes were cut to two eyes and dropped, one piece in a place, 16 inches apart, in rows 33½ inches apart. The soil is a clay loam, with sufficient sand to render it friable and easily tillable, and is known as oak and chestnut land. The land was cleared in the winter of 1893-94 and cropped with corn in 1894. Each row contained 204 hills, and all of the varieties were planted in duplicate, except a few of the new kinds, sent in for trial. The average yields are given in the table. The total yields of large and small are given, and in most cases the per cent. of small is stated under notes on varieties. Except in two or three cases the per cent. of small was not very great, although the season was uncommonly dry. Level cultivation was given. The same methods have been followed at the sub-stations, and in other seasons.

Since a number of varieties were added to the list in 1895 it is not possible to make a comparison for the years 1894–95 throughout, but a list of those grown in both seasons is given in Table II. The yield in 1894 was much less than in 1895, and none reached the same mark in the first as in the latter season.

The varieties which stood above the average in both seasons are American Wonder, Columbus, Carman No. 1, Early Norther, Forest Rose, Irish Daisy, King of the Mammoths, Koshkonong, Stoneroad's Nos. 1 and 2, Sir William, Van Orman's Superb, Victor Rose, Wilson's First Choice, World's Fair, Wisconsin Beauty. All of these varieties were not on the list in 1893, but the American Wonder, Columbus, Early Norther, King of the Mammoths, Koshkonong, Stoneroad's Nos. 1 and 2 and Wilson's First Choice stood above the average in all cases. None of the others were on trial in 1893, except World's Fair, and it fell slightly below the average for that season. Those which have for two or three seasons fallen below the average are Badger Bell, Burpee's Extra Early, Crown Jewel, Early Ohio, Everitt's Six Weeks, Minister, Salzer's Earliest.

In Table III is a comparison of varieties which were grown at the Central Station, and at the North Western and North Eastern Sub-Station, near Neapolis P. O., and in Strongsville township, Cuyahoga county.

The soil at Neapolis is sandy and the region is known as the "Oak Openings." It has been newly cleared, and cropped one season. The higher portions of the field are of yellow sand, and the lower of black sand.

The rows of potatoes extended across the black sand, both ends being on the yellow sand. The yield was calculated on the rows entire. This gave an average of about 92 bushels per acre, but on the black sand it was 116.

TABLE II.—COMPARISON OF VARIETIES OF POTATOES FOR 1894 AND 1895.

Variety.	Yields per acre.		
	1894.	1895.	Average for two season.
	Bushels.	*Bushels.*	*Bushels.*
American Wonder	169	276	**222**
Banner	117	201	**159**
Columbus	182	281	**231**
Carman No. 1	141	262	**201**
Clay Rose	155	214	**184**
Early Norther	130	270	**200**
" Rose	120	217	**168**
" Puritan	87	298	**192**
" Ohio	67	207	**137**
" Harvest	95	290	**192**
Everitt's Six Weeks	75	202	**138**
Freeman	87	237	**162**
Forest Rose	134	304	**219**
Irish Daisy	129	247	**188**
Illinois Queen	71	229	**150**
King of the Mammoths	149	330	**239**
Koshkonong	119	309	**214**
Maggie Murphy	112	238	**175**
New Burbank	116	237	**176**
New Queen	99	254	**176**
Nebula	96	266	**181**
Pennsylvania's Best	107	283	**195**
Penn Manor	96	252	**174**
Rural New Yorker No. 2	138	213	**175**
Stoneroad's No. 1	134	258	**196**
" No. 2	115	288	**201**
Salzer's Earliest	55	177	**116**
Sir William	144	308	**226**
Van Orman's Earliest	97	249	**173**
" " Superb	129	236	**182**
Vick's White Gem	69	159	**114**
Victor Rose	121	244	**182**
Wilson's First Choice	135	232	**183**
World's Fair	126	266	**196**
Wisconsin Beauty	139	269	**204**

The soil at Strongsville is a heavy clay, much below the average soils of the state in fertility. The only place available for potatoes was a timothy sod, which could not be gotten into good condition for potatoes, which partly explains the wide variations in yields.

Neither of these sub-station trials of varieties was satisfactory, not because of low yields, but because the soil could not be brought into the proper condition to insure uniformity, and this is especially true of the Northeast Sub-Station. Both present some interesting facts regarding the ability of certain varieties to yield crops under unfavorable conditions.

TABLE III. YIELDS OF VARIETIES OF POTATOES AT THE CENTRAL STATION AND SUB-STATIONS IN 1895.

Variety.	Yield per acre.			
	Central Station.	N. W. Sub-Sta.	N. E. Sub-Sta.	Average.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
American Wonder	276	94	106	159
Banner	201	81	68	117
Carman No. 1	262	93	76	144
Columbus	281	121	112	171
Clay Rose	214	78	74	122
Early Norther	270	77	66	138
Early Cyclone	261	92	80	144
Early Harvest	290	82	63	145
Everitt's Six Weeks	202	76	74	117
Forest Rose	304	77	76	152
Irish Daisy	247	94	169	170
Koshkonong	309	108	115	177
Maggie Murphy	238	76	68	127
Nebula	266	77	68	144
New Burbank	237	73	95	135
Pennsylvania's Best	283	103	114	167
Penn Manor	252	104	88	148
Rural New Yorker No. 2	213	108	104	142
Sir William	308	115	154	192
Stoneroad's No. 2	288	105	145	180
Timpee's No. 4	223	85	106	138
Victor Rose	244	101	62	136
Van Orman's Earliest	249	93	36	157
World's Fair	266	85	95	149

Among the varieties which stood above the average in a two season's trial at the Central Station, we find at both sub-stations, American Wonder, Columbus, Irish Daisy, Koshkonong, Sir William and Stoneroad's No. 2. Carman No. 1, Early Norther, Forest Rose and Victor Rose dropped slightly below the average at either one place or the other, although the greatest falling off was at Strongsville.

Irish Daisy seemed to endure hardship the best of any, but since it gave a larger percent of small potatoes than any other the Sir William is really at the head. In a two season's trial at Neapolis, Burpee's Extra Early has excelled the Early Norther, the reverse of the results at Wooster. This is the only really anomalous case of the kind, although Everitt's Six Weeks and Nebula approach it. It will not do to hastily conclude that the Early Norther and Nebula are not suited to a sandy soil, for both gave low yields at Strongsville, on a clay soil.

There are a number of varieties which have, in all our trials, occupied intermediate places in yield, neither reaching very near to the top nor falling close to the bottom. Among these may be named Clay Rose, Early Rose, Maggie Murphy, New Queen and Rural New Yorker No. 2.

Nothing is more clear than the fact that there are comparatively few varieties that show any great degree of uniformity and that all are not alike in this particular. That stable varieties are more valuable than those which fluctuate widely hardly needs to be said, and yet we have evidence that most people are anxious to get the variety which yielded the highest in a given trial, and often are ready to discard old reliable sorts, and to buy new kinds at high prices, which are reported as yielding three or four times as much as their own.

SECOND CROP SOUTHERN SEED VS. NORTHERN SEED.

In 1893 second crop seed of the following varieties was procured from Maryland and of the same varieties from both Maine and Wisconsin: Early Rose, New Queen, Burpee's Extra Early and Crown Jewel.

Owing to unfavorable weather the planting was delayed for some time after the potatoes were received. Those which came from Maine and Wisconsin sprouted considerably, while the second crop seed showed almost no signs of sprouting. The seed was all in excellent condition when received, and was of the best quality in every particular. The yield was slightly in favor of the second crop seed except in the case of the Early Rose. The average was slightly in favor of the northern seed, the rate of yield per acre being 170 bushels from second crop seed and 171 from northern seed. In 1894 the crop from the southern seed was at the rate of 105 bushels per acre and 102 from the northern seed. The experiment was not repeated in 1895.

These results are not conclusive, nor do they afford any basis for generalization.

The slow sprouting of the southern second crop seed is in its favor. The potatoes average smaller than those from the north, hence if cut with the same number of eyes to the piece will go farther in planting. We have not been able to note that difference in earliness of crop in favor of the second crop seed, which has been claimed. On the whole it does not appear that second crop seed is superior for this latitude to northern seed, although it may be for sections further south. More extended experiments are really needed to settle the question, however.

Our own seed, if well kept, appears to be as good as either northern or southern seed. By planting late, about the first of July, it is possible to grow potatoes for seed here, which appear to have a greater value for seed purposes than the crop which is grown at the usual season.

Experiments to test this matter have been started.

NOTES ON VARIETIES.

American Wonder. A comparatively new midseason variety of great value. The vines are vigorous and do not blight as quickly as most kinds, but are not exempt. It is one of the most prolific varieties, standing near the head of the list in all our trials. The potatoes are white; medium to large; quite uniform in size and regular in shape. It has been sold, even quite recently, at exorbitant prices by agents, but those who received genuine stock in this manner secured a better bargain than is usual in such cases. It keeps well and is of good quality.

Acme (Seedling) (Vaughan). Closely resembles Early Ohio in appearance of tubers, but is a stronger grower, and perhaps more prolific. Vaughan says of it, "The Acme Seedling is fully a week in advance of any other kind in earliness." It appears to rank with Early Ohio in earliness here, but is not quite as early as Bliss' Triumph. It has been grown here only one season, and in small quantity, but it appears to rank with the best early sorts, and it may be regarded as promising. Although the tubers are of fair size the per cent. of small potatoes, as in the Early Ohio, was quite large, viz.: 19. If it should prove to be superior to Early Ohio it will be in vigor and productiveness. Quality good. Keeps better than most early varieties.

Banner (Livingston). A second-early variety, of recognized merit. It bears a close resemblance to the Rural New Yorker No. 2, Peerless Jr., Harvest King and Carman No. 3, both in appearance of plants and tubers, although of distinct origin. It occupies an intermediate place in point of productiveness, and in all our trials has stood near, but a little below the Rural New Yorker No. 2.

Bovee M. An unnamed variety, sent for trial by Mr. Bovee of Michigan. Judging from one season's trial this is a very promising variety, but a longer time is needed to determine its value. Season, early to medium; plants very vigorous in growth, resists blight well, but not exempt. Very prolific, as indicated by one season's trial. The tubers are medium to large, of medium length and somewhat flattened; sometimes nearly oval in outline; eyes variable in size, but mostly shallow; color pink. Quality good. Aside from a tendency to grow prongy this is an uncommonly promising variety. 15 per cent. small.

Carman No. 1 (Thorburn). A valuable midseason variety. More prolific and vigorous in growth than the Rural New Yorker No. 2 has been here, but has blighted earlier in the season. The tubers are medium to large in size, usually oval in outline, but sometimes the ends are nearly square; somewhat longer than the Rural New Yorker No. 2. Color white with more or less russet; eyes shallow. In our trials it has fallen somewhat below the most prolific sorts in yield, but it has given good crops. 12 per cent. of the crop was graded as small last season. A good keeper but not always of the best quality.

Carman No. 3 (Thorburn). Resembles the Rural New Yorker No. 2 very closely in appearance of both plants and tubers. The potatoes received from the introducer, however, were much longer and quite distinct from the above variety, but as grown here, the past season, the two varieties seem to be very similar in every particular. There is possibly some difference in favor of Carman No. 3 in both vigor of growth and yield. It appears to resist blight better than Carman No. 1, but is not exempt from that disease. The quality was not satisfactory this season.

Columbus. This variety has uniformly given good yields here, and ranks among the most prolific sorts. The tubers are sometimes rough and uneven, but aside from this it is one of the most profitable varieties that has been grown here.

Clay Rose (Dibble). A second early variety; quite distinct in habit of growth; vigorous but only moderately prolific. Dibble says that it is so desirable in color and form that it will sell in market for Early Rose, but we find it quite different from the Early Rose in appearance, and decidedly inferior. He also says that it may be considered as blight proof, but it has blighted here. Judging from the results of two season's trials, it appears to have no qualities of great value.

Craig (Root). A late variety of vigorous habit of growth. Judging from reports it is very prolific, but the yield was small here, as the vines were almost killed by blight before the middle of August. In form the tubers are short, often nearly spherical, but usually slightly flattened. Rather rough and uneven, with a depression at the stem end. Eyes rather deep; skin pink. In spite of the fact that the vines were killed by blight, which prevented the proper maturing of the crop, there were only eight per cent. of tubers below marketable size. The principal objections to the variety are its lateness, also color and form of tubers. No doubt it will prove to be a great cropper wherever it ripens before blighting.

Early Norther. This is the most promising variety of the Rose class that has been tested here for any considerable period. In form and color it resembles the Early Rose, but is more prolific. On the sandy soil of the sub-station at Neapolis it has not been as satisfactory as some other early sorts, notably Burpee's Extra Early, but on clay soil it has given satisfaction as far as known. In quality it is unexcelled, and keeps as well as any of its class.

Early Everitt (Everitt). This is another promising variety of the Rose family. It compares favorably with Early Norther in yield, and is rather smoother, hence presents a better appearance. It is a strong competitor of that variety.

Early Cyclone (Salzer). Resembles the Early Harvest, but has given a smaller yield here. Salzer claims that it will yield three times as much as Early Ohio, or Early Rose, but it has about equalled the latter, and slightly exceeded the former here. He claims also that is earlier than either of these varieties by eight to twelve days, but in our trials it has ripened with the Early Rose. In fact, our trials have not substantiated any of the claims made for it. We must admit that it is a good variety, however.

Early Morn (May). May does not give a description in his catalogue by which we may judge whether this is a white or pink potato, and as tubers of both colors were in the lot sent here it was taken for granted that the unfamiliar kind was Early Morn, especially as the other was identified as Early Ohio. May says that the Early Morn is the earliest potato in the world, but it is not so here, nor does it appear to possess many specially valuable qualities Quality excellent.

Early Harvest (Jerrard). An early white variety of great value. Our trials do not substantiate Jerrard's claim that it is earlier than any other potato that is grown, but it appears to be about as early as Early Rose and Early Puritan. It stands near the head of the list among early white sorts in vigor, productiveness and quality.

Early Pinkeye (Read). Ripens with Early Harvest. Vines rather spindling in growth and subject to blight. Tubers rather short, often nearly oval, flattened; eyes pink, shallow; skin nearly white. A fine potato, but often uneven and irregular. Compares favorably in yield with other early sorts. Quality good, but does not keep well.

Everitt's Six Weeks (Everitt). Just wherein this variety differs from Early Ohio and Ohio Junior seems not to have been made clear by the disseminators nor by any one else. No. 177, grown by the Station, and given to the public several years ago, is another of the same class, and possibly more prolific than any of the others. No doubt half a dozen varieties of this class are in existence, and although of distinct origin are practically identical. They rank next to Bliss' Triumph in earliness, but excel those of that class in prolificacy, and yet are not sufficiently productive to meet the general demands for an early variety. For special purposes the Early Ohio class is invaluable, and it matters but little under what variety name the stock is secured, except that there seems to be a growing difficulty in securing pure seed of the Early Ohio, and for this reason it may sometimes be advisable to purchase stock under one of the other names.

Freemen. This variety is widely and favorably known because of its good table qualities. Comparatively few have succeeded in getting good yields with it, because it requires a rich soil and high cultivation. It sets a comparatively large number of tubers, hence the seed must be cut to one eye and the best possible conditions furnished, or a large per cent. of the crop will be small. The per cent. of small potatoes last season was 26, in spite of the fact that the soil was fertile and the cultivation as good as could be given. This was the highest per cent. of small potatoes of any variety tested.

Forest Rose. A medium early white variety. The vines are vigorous but quite subject to blight. It ranks quite high in productiveness, but the tubers lack uniformity. The best present a beautiful appearance, but taken as a whole they are somewhat dissapointing. The general shape of the tubers is long and almost cylindrical. The two ends are about equal in size and rounded. Eyes shallow. Skin white. Excellent for baking. Per cent. of small, 17.

Great Divide (Burpee). A late white variety, of vigorous habit of growth, ranking medium as to prolificacy. It is said to be blight and scab proof, but we have not found it so, although it does not blight as early as most other kinds. The tubers are uniform in size, regular in shape and present a fine appearance. The keeping and table qualities are good. Although not the most prolific of the varieties tested here it will no doubt prove to be a profitable market sort. The percentage of small was 19 this season, which indicates the habit of setting too many tubers.

Harvest King (Salzer). Salzer says that it is very distinct in appearance, but we were unable to distinguish it from the Rural New Yorker No. 2, either in habit of growth or in appearance of tubers. It may be distinct from that variety in origin, but does not appear to be superior to it in any respect.

Irish Daisy (Maule). A midseason white variety, of vigorous habit of growth; not so much subject to blight as most other sorts, but not entirely resistant. It is a good cropper, but a very large per cent. of the tubers are small, standing next to the Freeman in this particular. Even when the small potatoes are sorted out, leaving only those of marketable size, the general appearance is far from pleasing, because of the rough, uneven character of the tubers. A good keeper, but was not of the best quality this season.

King of the Earliest (Salzer). Resembles the Early Ohio in form and color. It ripens at about the same time as the Early Ohio, and yields about the same. Possibly its growth is more vigorous, while the tubers appear to be rather longer, with deeper eyes. How constant these slight differences are, or whether they exist at all or not, must remain to be determined by further comparison.

Lightning Express (from both Dibble and Salzer). We have been unable to distinguish this variety from Maggie Murphy, as obtained from Dibble, but those from Salzer were mixed.

Maule's Thoroughbred (Maule). This was sent here for trial by Wm. H. Maule, as No. 17. It ripens with the Early Rose. The vines are quite vigorous and slow to blight, but are not exempt. Our trial indicates that it is very prolific, but as we had only fourteen hills, from which the yield per acre was calculated, there is possibility of considerable error, as a slight variation is thus multiplied more than eight hundred times. The tubers are medium to large, of medium length, slightly flattened; often nearly oval in outline; eyes shallow; rose color. This gives indications of being a valuable variety. Quality good.

Maggie Murphy (Vick). A midseason pink potato, of vigorous growth, ranking medium as to productiveness, in our trials. It is not blight proof, as claimed, as our notes show that the vines were badly blighted August 12. The tubers are large and coarse looking, and are not always of the best quality, especially if grown on heavy land. The per cent. of small was low, being only 6. In some markets it would not find a ready sale, because of the color and coarse appearance. Does not sprout quickly.

New Northern (May). A vigorous growing, intermediate variety, claimed by May to be the heaviest yielding potato in the world, but it has not taken that rank here, being considerably below some of the best in yield. The tubers are medium to large, rather long, sometimes nearly cylindrical but usually slightly flattened, eyes shallow, skin white with some russet. Quite uniform and of fine appearance. Quality good, but does not keep as well as some.

Onward (Everitt). A midseason, vigorous growing variety. Does not blight early, but is not resistant. It gave a good yield last season, with only 7 per cent. of unmarketable tubers, but it fell considerably below the most prolific sorts. The tubers are rather long, almost slender, flattened, eyes shallow, skin white, with more or less russet. Quality good; suitable for baking. Although tested but one season it seems safe to rank it as promising.

Pennsylvania's Best (Stoneroad). An early to medium, strong growing variety, resisting blight quite well. Quite prolific; tubers of medium length, slightly flattened, sometimes nearly cylindrical; eyes shallow; rose color; promising. Of good quality, but does not keep as well as most other varieties.

Penn Manor (Johnson & Stokes). Claimed to be earlier and a heavier cropper than the Early Rose, which it resembles, but it has not proved to be superior to that variety here. Does not keep well.

Peerless Jr. (Dibble). This is claimed by Dibble to be an early variety and is said to be blight proof, but it is not early here, nor does it resist blight. It so closely resembles the Rural New Yorker No 2 that the same description answers for both. Just wherein the two varieties differ remains for further comparison to show. According to Dibble it has a distinct origin, but that does not prove its superiority.

Parker's Market (Jerrard). A second early, rose colored variety, of vigorous growth and moderate productiveness. It is not exempt from blight, but does not succumb early. Tubers rather short and nearly oval in outline, ends often nearly square; eyes shallow; skin rose color.

Rural New Yorker No. 2. A well known, intermediate, white variety. In yield it falls below some of the most prolific, and the quality is not always first class, but in general reliability it is hardly excelled. Six per cent. of the crop was small.

Somerset (Jerrard). A midseason variety of great vigor, comparatively free from blight, but not wholly exempt. It will probably take rank above medium as to productiveness, but it barely reached that point here last season. The tubers are quite short, considerably flattened; eyes rather deep; skin rose color. No doubt this will prove to be a valuable variety, although in some markets potatoes of this description are not in demand, and sell for less than white skinned sorts. Eight per cent. of the crop was unmarketable. Quality excellent.

Salzer's Earliest (Salzer). We have been unable to find any difference between this and Stray Beauty, or Bliss' Triumph. It is very early, but a light cropper.

Sir William (Burr). A vigorous and prolific late white variety. It resisted blight longer last season than most varieties, and the yield was considerably above the average, but not quite equal to that of the best. Complaint has been heard that the tubers are coarse in appearance and poor in quality, but we have found none to be superior to it in quality, and but few equal to it in appearance. It is an almost ideal potato, both for home use and for market. It stands in the list of the very few varieties which have, for two seasons, given the highest yields on both old and new ground at the Central Station in Wayne county, on the thin, sandy soil in Fulton county, and the heavy clay in Cuyahoga county. These trials indicate that it will respond to good treatment, almost equally with the heaviest cropping varieties, and will endure hardship better than the average. There are some early and medium varieties equal to it in quality, but it excels most, if not all, of the heavy cropping, late sorts, in this particular. All things considered it deserves a place very near the head of the list.

Stoneroad's Main Crop Nos. 1 *and* 2. (Stoneroad). Two midseason, strong growing, white varieties, of considerable merit. Both have given good yields three seasons, and stand rather above the average. No. 2 has produced slightly more than No. 1. Both are of good quality and keep well.

Vick's Early Pride. An early variety, resembling the Early Rose, and ripening at about the same time. It seems to yield more than that variety, and may prove to be superior to it.

Victor Rose (Dibble). A midseason, rose colored potato, of vigorous habit of growth; resists blight longer than most kinds. It gives about an average yield of shapely potatoes of good quality, with a small per cent. of unmarketable tubers.

Van Orman's No. 99. (Van Orman). This variety has been tested in a small way, one season only. It is an early white variety of considerable promise, especially because of extreme earliness and shapely tubers. It appears to be the earliest of any white variety thus far tested. It yields well for such an early ripening kind.

Wolfgang. An unnamed, early ripening sort, of the Early Rose type, received from H. G. Wolfgang, for trial. It resembles the early Everitt in form. It gave an exceptionally high yield on a small plot, and it remains to be seen what it will do on larger areas and in other soils and seasons, but it appears to have considerable merit. Quality good.

Wood's Earliest. (Wood). A free growing, comparatively prolific, early white variety. It seems to have considerable merit, because of its earliness, but further comparison with other varieties is necessary.

Wise. (D. W. Wise). A very vigorous and prolific, second early variety. The tubers are rather long and quite thick, slightly flattened; ends nearly square, sometimes tapering; eyes rather deep; skin pink, almost white. It is said to grow prongy sometimes, but that tendency has not been observed here. This variety has a local reputation in Ashland county, and has been on trial only one season here, but judging from reports and its behavior here it has more than ordinary merit. It keeps well and is of good quality.

FERTILIZER EXPERIMENTS.

Experiments with fertilizers are now carried on at the Central Station at Wooster, on a clay loam, known as oak and chestnut land; at the Northwestern Sub-Station at Neapolis, on yellow sandy soil and at the Northeastern Sub-Station at Strongsville, on a heavy clay soil.

The plots at the Central Station are $\frac{1}{10}$ of an acre each and at the sub-stations $\frac{1}{20}$ of an acre each.

The rotation is potatoes, wheat and clover. The following is a plan of the work for potatoes:

Plot 1. Unfertilized.
" 2. Superphosphate, 160 pounds.
" 3. Muriate of potash, 100 pounds.
" 4. Unfertilized.
" 5. Nitrate of soda, 80 pounds.
" 6. Superphosphate, 160 pounds; Nitrate of soda, 80 pounds.
" 7. Unfertilized.
" 8. Superphosphate, 160 pounds; Muriate of potash, 100 pounds.
" 9. Nitrate of soda, 80 pounds; Muriate of potash, 100 pounds.
" 10. Unfertilized.
" 11. Superphosphate, 160 pounds; Nitrate of soda, 80 pounds; Muriate of potash, 100 pounds.
" 12. Superphosphate, 160 pounds; Nitrate of soda, 160 pounds; Muriate of potash, 100 pounds.
" 13. Unfertilized.
" 14. Superphosphate, 320 pounds; Nitrate of soda, 160 pounds; Muriate of potash, 200 pounds.
" 15. Superphosphate, 480 pounds; Nitrate of soda, 320 pounds; Muriate of potash, 300 pounds.
" 16. Unfertilized.
" 17. Unfertilized.
" 18. Unfertilized.
" 19. Unfertilized.
" 20. Superphosphate, 80 pounds; Bran, 500 pounds; Muriate of potash, 85 pounds.
" 21. Superphosphate, 120 pounds; Linseed meal, 200 pounds; Muriate of potash, 95 pounds.
" 22. Unfertilized.
" 23. Superphosphate, 160 pounds; Dried blood, 100 pounds; Muriate of potash, 100 pounds.
" 24. Superphosphate, 160 pounds; Sulphate of ammonia, 60 pounds; Muriate of potash, 100 pounds.
" 25. Unfertilized.
" 26. Bone meal, 110 pounds; Nitrate of soda, 55 pounds; Muriate of potash, 100 pounds.
" 27. Acid Phosphate, 170 pounds; Nitrate of soda, 80 pounds; Muriate of potash, 100 pounds.
" 28. Unfertilized.
" 29. Basic slag, 130 pounds; Nitrate of soda, 80 pounds; Muriate of potash, 100 pounds.
" 30. Barnyard manure, 8 tons.
" 31. Unfertilized.

In all cases the number of pounds given means pounds per acre. It is intended that plots 20, 21, 23, 24, 26, 27 and 29 shall receive the same total quantity of nitrogen, phosphoric acid and potash as plot 11, but in different forms.

TABLE IV.—FERTILIZERS ON POTATOES AT THE CENTRAL AND BRANCH STATIONS, SHOWING THE INCREASE IN BUSHELS PER ACRE.

Plot.	Central Station, average for 1894 and 1895.	Northwestern Station, average for 1894 and 1895.	Northeastern Station for 1895.
2	28.5	8.6	16.7
3	3.9	23.4	–8.7
5	0.5	6.0	6.1
6	29.4	14.4	13.7
8	36.1	11.0	21.2
9	19.4	11.6	–8.7
11	31.2	20.8	8.0
12	51.3	24.5	31.6
14	56.2	29.8	19.9
15	66.1	36.8	45.6
20	43.0	3.2	30.6
21	37.6	18.5	14.3
23	47.0	14.7	15.5
24	47.7	11.3	31.5
26	26.1	–7.8	19.7
27	31.3	11.5	18.2
29	23.0	5.8	13.6
30	28.3	......	23.0

The average unfertilized yield at the Central Station for the two seasons was 112.4 bushels; at the Northwestern Sub-station 74.4 bushels, and at the Northeastern Sub-station 59.8 bushels per acre for 1895.

It should be stated that the land at the Northwestern Sub-station has been recently cleared and is not thoroughly subdued, hence irregularities in yield, while at the Northeastern Sub-station it was necessary to use a timothy sod for potatoes, and it was not possible to get it into a good condition for the crop. In most cases the per cent. of gain was higher at the Central Station than at the Northwestern Sub-station and lower than at the Northeastern Sub-station, but there are some exceptions.

The greatest profit in the use of fertilizers was found in every case at the Central Station. If we compare the cost of the increase in the use of the various fertilizers we find that superphosphate alone added to the crop at the least cost per bushel. At the Central Station there was an increase of crop in the use of superphosphate of 28.5 bushels, at a cost of $1.44, or about 5 cents per bushel. At the Northwestern Sub-station the cost of the increase was a little more than 16 cents per bushel, and at the Northeastern Sub-station about 8 cents.

Muriate of potash has increased the crop somewhat, and apparently most on the sandy soil, but as the results are contradictory it is not possible to interpret them On the average its use has given no profit.

Nitrate of soda seems to have been almost entirely lost on the crop thus far when used alone. When muriate of potash has been used with superphosphate there has been an increase in the crop more than their use separately seemed to indicate, and the same is in a measure true of nitrate of soda. When the three were used in combination, and in larger quantities, up to 1,100 pounds per acre, the increase in bushels has kept pace with the added quantities of fertilizers. In 1894 the greatest profit was realized in the use of the largest quantity of fertilizers, with potatoes at 50 cents per bushel, but in 1895 the increase was secured at a cost of about 30 cents per bushel,which left no margin for profit, reckoning potatoes at market value.

The combination of superphosphate, muriate of potash and nitrate of soda has, at the Central Station, increased the crop at a cost of about 19 cents per bushel, but on the average the cost of the increase has been nearly 10 cents per bushel more than that.

Where sulphate of ammonia has been substituted for nitrate of soda, the cost of the increase has been lowered to about 12 cents per bushel, and the same figures hold good for dried blood, used in the place of nitrate of soda. Where acid phosphate has been used the cost of the increase in the average for two years at the Central Station has been about 20 cents per bushel, and for basic slag about 25 cents. The average in all of the experiments with these two has been 22.2 and 29.2 cents per bushel respectively.

With potatoes at the selling price in 1894 there was a handsome profit in the use of all of the various mixtures, and averaging the results of two seasons and taking the average price for potatoes there is still a fair profit; but with the selling price of potatoes at 25 to 30 cents per bushel, as in 1895, the profit in most cases disappears, and seems to be dependent almost wholly upon the presence of phosphoric acid. Thus far in all of our experiments, at Columbus as well as here and at the branch stations, phosphoric acid has been the controlling factor in the increase of the potato yields. It has not produced crops equal to a complete fertilizer, but while it alone has always shown a profit, the addition of the other elements has not always made the profits larger.

It is too early to discuss this matter from the results of our own experiments, but the evidence that we have thus far seems to indicate that a complete fertilizer, high in phosphoric acid and nitrogen, and low in potash has given the best results.

These matters will be discussed more fully in a bulletin on fertilizers.

SUMMARY.

Variety trials of potatoes have been made at the Central Station, on a clay loam, at the Northwestern Sub-station, on a sandy soil and at the Northeastern Sub-station on a heavy clay soil.

The plan of work is to devote about $\frac{1}{60}$ of an acre to each plot, and to duplicate the tests, at each place, as far as possible.

Varieties are known to vary on different soils, but it is an error to suppose that this is the prime cause of variation, and that all are alike as to variability.

If these suppositions were true, then no variety trial would have either local or general value.

The fact that some varieties are quite constant in their behavior under widely different conditions, gives a clue to the determination of the best ones for the general public; but the results of a single trial must be regarded merely as suggestive, and not conclusive.

It is only by summing up of different results that variety trials can have any value, either local or general, and to secure the latter a longer time is required, with a correspondingly reduced list.

The varieties which have stood the highest in yield at the Central Station in 1894 and 1895 are American Wonder, Columbus, Early Norther, Forest Rose, Irish Daisy, King of the Mammoths, Koshkonong, Stoneroad's Nos. 1 and 2, Sir William, Van Orman's Superb, Victor Rose, Wilson's First Choice, World's Fair, Wisconsin Beauty.

Those which have fallen below the average are Badger Belle, Burpee's Extra Early, Crown Jewel, Early Ohio, Everitt's Six Weeks, Minister, Salzer's Earliest.

The varieties which have averaged highest at the Central and both Sub-stations are American Wonder, Columbus, Irish Daisy, Koshkonong, Sir William and Stoneroad's No. 2.

It is clear, from our trials, that comparatively few varieties show any degree of uniformity, and it is equally manifest that varieties are quite unlike in this respect.

As a matter of course those which are least influenced by variations in soil, climate, treatment, etc., are the most valuable, and the above results may be taken as evidence which is not conclusive but suggestive.

Trials made with second crop southern seed and northern seed of the same varieties, have shown no decided differences in the yield from either, nor in earliness.

Our own seed, if well kept, seems to be as good as that from either source.

The following varieties seem to have considerable merit, although not sufficiently tested: Acme, Bovee, Carman No. 3, Early Everitt, Great Divide, Onward, Somerset, Van Orman's No. 99, Wolfgang, Wise.

In the following lists designated A, B, C, D and E are grouped varieties which resemble each other closely, although they may be of distinct origin:

A. Banner, Carman No. 3, Harvest King, Peerless Jr., Rural New Yorker No. 2.

B. Early Cyclone, Early Harvest.

C. Early Ohio, Everitt's Six Weeks, Ohio Jr., King of the Earliest.

D. Maggie Murphy, Lightning Express.

E. Salzer's Earliest, Stray Beauty, Bliss' Triumph.

In the use of fertilizers the lowest cost per bushel of increase in crop has been attained in the use of superphosphate alone, but the greatest gain per acre has been with 1,100 pounds per acre of fertilizer containing phosphoric acid, nitrogen and potash.

Muriate of potash and nitrate of soda when used alone have not given a profitable increase, but have proved beneficial in connection with superphosphate.

Phosphoric acid seems to have been the controlling element in an increase in the potato crop in all of our experiments.

APPENDIX.

BULLETIN

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

1895.

CONTENTS.

PAGE
Noxious weeds along thoroughfares and their destruction 1
Experiments in feeding for beef 7
The chemistry of cattle feeding 31
Comparative value of feeding stuffs 43
Sub-irrigation in the greenhouse 57
The grape-root worm 77
Orchard spraying 97
Notes on varieties of raspberries 108
The smut of oats 115
Variety trials with potatoes 141
Meteorological summary for 1895 161
Index 173

BULLETIN

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

NUMBER 66. December, 1895.

METEOROLOGICAL SUMMARY FOR 1895.

BY C. A. PATTON.

EXPLANATION OF TABLES.

The following tables contain statistics of temperature, rainfall, etc., for the year, and are compiled from data obtained by daily observations. T stands for "trace," less than .01 inch of daily rainfall. Temperature is given in degrees Fahrenheit.

Table I shows the daily rainfall at the Station during the year in inches and hundredths.

Table II shows the daily mean temperature for 1894, and the normal mean temperature for each day, computed from seven years' record.

Table III gives a comparison of the monthly mean temperature and rainfall for the Station and the State, with the nine years' average for the same.

Table IV shows the rainfall for the Station for each month during the last eight years.

Table V contains the mean temperature, the highest and lowest temperatures, with the range of temperature, for each month; the number of clear, fair and cloudy days; the rainfall and prevailing direction of wind, for both the Experiment Station and State, for 1895.

Table VI contains the principal points of interest on temperature, state of weather and rainfall for the Station during the year, and a grand summary for eight years.

Table VII contains the principal points of interest on temperature, state of weather and rainfall for the State during the year, and a grand summary for thirteen years.

The statistics for the State and for this Station, previous to 1893, are compiled from the publications of the Ohio Meteorological Bureau and State weather service, the seven-year average being computed from the observations of the Wooster Station of the Ohio Meteorological Bureau, which Station was located two miles north of its present site previous to March, 1892; then for two years in the city of Wooster, and since April, 1894, on the grounds of the Experiment Station, one mile south of Wooster.

METEOROLOGY—TABLE I.—RAINFALL.

DAILY RAINFALL AND MELTED SNOW FOR 1895 AT EXPERIMENT STATION.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1			.57	.13							T	T
2	.05			.05								.80
3								.08				
4			T	T		.17			.34			
5	T		T			.41			.03			
6	1.15	.30	.20		.40			.20	T			
7	.70	.45	T	.62	.06			.10	T	.02		
8	.05	.05	.09		T		.07				.90	T
9				.07			.07				.90	
10												
11	.30		T		.28			.50		.12		.30
12	.40	.10	.05	.33		T			3.28	.71		
13	.10		.60	.33	.10	.26						
14			.02	T	.22							
15			.08		.01		1.41				.12	
16			.08				.10		.08		T	
17	.20							.50				
18	.02	T							.07			
19					.16	.10					T	
20	.25				T	.30				T	T	
21	T					.91	T					.62
22				.10			.26			T	.10	
23							T				.45	
24	.20		.05			1.30		.02			.25	
25	35		.19		T				.12		1.10	.30
26			.05	T	.15	74		.20	T		.32	1.00
27		T		.06			.25	.25		.13		.13
28	.05	.10						.45				
29	.05		T			.01		T			.07	
30	.05			T		T					T	.24
31								T		.17		.12
Totals	3.92	1.00	1 98	1 69	1.38	4 20	2.19	2.30	3.92	1.15	4 21	3 51
Averages	.13	.04	.06	.05	.04	.14	.07	.07	.13	.04	.14	.11

METEOROLOGY—TABLE II.—TEMPERATURE.

N STANDS FOR NORMAL MEAN TEMPERATURE FOR EIGHT YEARS.

	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.	1895.	N.
1	15	36.32	15	30.24	41	21.78	43	45.91	66	34.08	81	63.18	66	68.87	61	69.08	60	62.45	46	55.51	34	47.63	40	31.85
2	12	28.95	14	29.26	26	50.66	34	43.51	65	54.96	79	63.92	60	68.75	63	69.86	58	63.26	49	53.75	33	47.51	33	31.41
3	21	24.85	17	28.67	34	31.35	32	45.20	67	55.73	80	67.17	62	67.26	67	69.75	67	65.86	52	58.08	41	41.73	17	32.42
4	28	30.86	14	27.03	27	27.78	42	46.03	71	57.32	80	65.63	62	65.17	68	68.37	74	69.42	52	53.52	47	40.61	20	28.53
5	16	30.50	1	21.83	21	25.76	50	46.52	74	56.01	65	63.07	68	66.63	72	68.32	71	67.11	51	51.88	50	42.48	20	31.17
6	39	33.25	—2	23.83	28	30.27	59	44.50	74	57.13	57	61.42	71	68.33	74	70.76	72	65.78	60	51.31	57	43.25	19	31.25
7	40	27.27	—2	26.06	23	30.45	56	48.46	70	55.40	54	58.25	74	70.07	72	69.62	73	66.95	56	50.78	60	46.80	23	32.15
8	28	25.88	—2	23.32	34	36.02	54	[illegible]	70	51.21	63	63.65	78	71.65	71	72.21	62	65.73	44	47.38	57	46.01	32	36.10
9	26	24.82	4	25.07	26	33.70	46	43.28	79	[illegible]	68	66.96	66	66.98	74	73.62	72	67.13	40	49.56	46	47.20	27	33.85
10	32	25.08	8	26.26	36	35.61	40	44.18	71	65.08	71	69.50	56	67.03	78	71.37	77	66.93	38	48.27	34	40.15	23	34.51
11	33	28.85	13	26.26	30	37.92	38	56.45	62	57.95	72	65.50	62	69.57	80	69.53	78	66.86	53	51.76	35	38.95	23	34.03
12	13	25.90	8	22.40	33	36.52	46	46.75	48	51.71	70	66.33	70	72.08	76	68.42	77	67.12	46	51.15	33	38.73	22	33.35
13	3	23.36	8	25.85	36	34.65	49	49.61	40	52.76	72	68.43	70	72.48	68	66.05	66	63.78	46	49.86	36	40.18	12	29.81
14	11	24.23	18	29.72	22	28.45	46	44.33	40	53.36	70	70.02	65	71.37	67	65.87	58	63.45	48	45.58	43	39.85	14	31.70
15	20	23.36	20	26.38	18	28.95	44	43.27	48	57.75	68	72.17	74	71.43	72	68.66	54	65.06	43	46.70	41	40.58	24	37.65
16	26	23.83	16	30.66	19	30.96	44	43.80	46	52.57	67	72.76	74	69.42	75	70.00	66	62.01	48	49.28	38	40.43	30	38.05
17	19	24.41	22	33.61	24	35.10	44	51.35	44	55.60	72	72.52	74	71.55	78	69.56	72	60.90	45	49.95	41	38.43	37	31.67
18	22	26.07	30	32.48	36	38.32	46	50.82	50	60.51	68	71.60	68	69.67	72	69.67	78	63.05	46	48.82	43	36.42	46	31.60
19	33	24.46	26	29.41	32	38.51	48	50.83	56	55.01	72	70.72	76	70.18	65	68.22	80	64.52	46	49.32	42	36.02	51	33.37
20	31	25.61	24	26.96	29	40.88	50	49.53	46	53.73	68	70.62	78	68.36	64	68.10	76	62.01	34	45.65	32	34.06	57	34.23
21	44	25.43	32	27.13	26	39.56	54	51.71	41	53.95	68	71.51	84	70.06	62	67.20	77	72.07	36	46.41	31	38.76	49	35.10
22	27	24.72	22	27.26	28	35.60	52	44.63	48	56.22	68	71.60	78	72.30	64	62.18	77	65.35	50	47.91	35	37.67	39	35.10
23	17	29.28	21	29.33	40	38.78	52	51.31	56	55.06	68	71.65	67	70.35	77	65.33	66	63.31	38	45.68	44	34.63	51	36.62
24	12	26.01	22	31.98	48	39.55	56	47.11	60	60.11	71	70.97	63	69.16	75	67.91	54	59.40	36	45.67	38	33.98	58	39.73
25	19	25.84	35	32.78	44	37.77	63	47.92	68	59.66	74	69.83	66	70.03	69	69.21	51	57.41	46	47.13	43	31.72	52	40.16
26	29	28.31	32	29.55	34	38.10	62	53.90	69	58.60	78	70.62	66	70.43	68	69.20	69	57.35	46	47.08	46	33.42	41	32.36
27	14	24.02	37	30.63	40	36.08	54	55.00	50	56.45	72	68.48	70	71.82	74	67.95	55	54.53	46	43.67	32	36.61	33	26.41
28	12	25.55	49	33.93	44	34.67	56	36.41	58	57.30	69	68.51	62	70.82	75	65.71	51	54.78	37	42.25	35	30.32	31	27.30
29	15	28.07	....	....	42	36.12	61	55.45	72	60.55	66	69.32	66	71.98	76	65.80	54	54.11	32	41.21	36	31.55	32	29.81
30	14	27.62	....	....	42	39.67	64	[illegible]	79	64.55	67	69.87	66	71.15	71	65.76	44	54.26	32	41.67	34	31.06	33	26.90
31	12	31.22	....	....	41	45.57	....	....	80	61.06	....	....	58	71.53	70	54.58	....	....	34	43.72	....	....	29	31.10
Mean	21.9	26.90	17.9	28.13	32.4	35.32	49.5	48.10	59.4	56.42	69.9	68.19	68.6	69.88	70.9	67.99	66.5	63.06	44.2	48.40	40.4	38.89	32.8	32.97

Having no readings for August, 1891, 15-31, inc., and February, 1892, 9-22, inc., the readings were taken from Ashland Station, which is about 22 miles west of Wooster, and has the same latitude within one minute, and the same elevation within 16 feet of the Station at which the Wooster observations were taken previous to 1892.

METEOROLOGY—TABLE III.

Mean Temperature and Rainfall for the Station and State, 1895. Temperature in Degrees Fahrenheit, Rainfall in Inches.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Mean temperature at the Station, 1895	21.8	17.9	32.4	49.5	59.4	69.9	68.6	70.9	66.5	44.2	40.4	32.8	47.8
Nine years' average temperature at the Station	27.4[*1]	26.4[*2]	34.7	48.3	57.3[*3]	68.5	71.9	68.4[*3]	62.6	48.2	37.4	32.5	48.6
Mean temperature for the State, 1895	23.4	19.6	35.5	51.7	61.1	72.0	71.6	73.5	69.0	46.9	41.3	33.9	49.9
Nine years' average temperature for the State	28.4	30.9	27.1	50.4	60.0	71.0	73.1	70.6	64.6	50.5	40.4	34.2	50.1
Rainfall at the Station, 1895	3.92	1.00	1.98	1.69	1.38	4.20	2.19	2.30	3.92	1.15	4.21	3.51	31.45
Nine years' average rainfall at the Station	3.51[*3]	3.79[*1]	2.78	2.59	4.23	4.71	3.09	2.43	3.02	2.63	3.35	2.51	32.2
Rainfall for the State, 1895	4.00	0.69	1.59	2.11	1.80	2.44	2.00	2.96	1.66	1.22	4.11	3.85	38.64
Nine years' average rainfall for the State	3.05	3.44	2.82	3.03	3.92	3.85	2.93	2.95	2.63	2.30	3.25	2.51	30.50

[*1] Seven years. [*2] Six years. [*3] Eight years.

METEOROLOGY—TABLE IV.

MONTHLY RAINFALL FOR EIGHT YEARS AT WOOSTER.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1888	3.52	2.43	3.34	2.48	3 82	2.31	4.54	4.35	1.92	3.18	4.95	1.39	38.23
1889	4.33	2.42	2.13	1.58	2.97	4.86	6.73	1.98	4.05	1.36	3.53	3.93	39.87
1890	4.71	6.20	4.57	3.10	6.01	5 57	2.67	4.66	5.12	7.45	2.61	1 74	54.21
1891	2.74	4.83	3.71	1.66	2.24	7.13	3.28	1.85	0.94	1 33	5.73	2.92	38.36
1892	2.67	....	3.38	2.44	7.69	7.89	4 73	2.69	3.20	0.37	2 06	1.74	38.86
1893	4 01	6.33	1.89	5.66	6.28	2.51	1.38	1.53	1.85	5.18	2.48	1.50	40.61
1894	2.19	3 37	2.36	1.74	4.41	2.23	1.38	0.76	4.07	2.53	2.41	3.15	30.60
1895	3.92	1.00	1 98	1.69	1.38	4.20	2.19	2 30	3.92	1.15	4.21	3.51	31.45
Averages	3.51	3.79	2.92	2.54	4 35	4.59	3.36	2.51	3.13	2.82	3.50	2.48	39.02

METEOROLOGY—TABLE V.

SUMMARY BY MONTHS FOR 1895.

	Temperature.											Number of days.				Monthly rainfall.	Average daily rainfall.	Prevailing wind.
	Mean.	Highest.	Date.	Lowest.	Date.	Range.	Mean daily range.	Greatest daily range.	Date.	Least daily range.	Date.	Clear.	Fair.	Cloudy.	Rain fell			
At the Station.																		
January	21.8	54	21st	—6	*1	60	18.0	38	*2	8	*3	6	6	19	15	3.92	.13	S. W.
February	17.9	60	28th	—6	5th	66	16.0	32	16th	2	8th	3	16	9	8	1.00	.04	N.W.
March	32.4	59	24th	9	7th	50	19.0	31	29th	8	13th	6	7	18	11	1.98	.06	*4
April	49.5	80	*5	21	3d	59	22.0	38	24th	7	*6	6	13	11	8	1.69	.06	N.
May	59.4	91	31st	27	21st	67	27.0	46	28th	12	*7	12	13	6	8	1.38	.04	S.
June	69.9	98	4th	35	7th	63	26.5	40	*8	8	20th	18	9	3	9	4.20	.14	N.
July	68.6	92	19th	42	10th	50	24.8	34	*9	12	30th	16	11	4	6	2.19	.07	N.
August	70.9	94	10th	42	22d	52	27.0	43	22d	15	29th	17	12	2	9	2.30	.07	N.
September	66.5	93	11th	34	30th	59	24.0	34	3d	14	26th	16	8	6	6	3.92	.13	S.
October	44.5	78	3d	19	30th	54	24.0	55	6th	13	*10	11	9	11	5	1.15	.04	N.W.
November	40.4	72	7th	18	21st	54	20.0	34	4th	1	27th	6	6	18	9	4.21	.14	S. E.
December	32.8	61	*11	—2	14th	63	14.0	31	14th	4	24th	8	7	16	8	3.51	.11	S. W.
Sums and averages	47.8	77.5	....	19.4	....	57.2	21.8	38	....	8.6	....	125	117	123	102	31.45	.08	N.
For the State.																		
January	23.4	62	*1	—19	13th	81	20.0	59	15th	2	*2	7	8	16	12	4.00	.13	S. W.
February	19.6	70	28th	—24	6th	94	19.0	50	11th	0	7th	11	9	8	6	0.69	.02	W.
March	35.5	86	30th	—7	5th	93	21.0	59	29th	3	*3	10	10	11	9	1.59	.05	S. W.
April	51.7	90	25th	16	11th	74	24.0	52	24th	3	*4	11	11	8	6	2.11	.07	N. E.
May	61.1	102	*5	19	21st	83	27.0	56	28th	3	*6	14	11	6	7	1.80	.06	S. W.
June	72.0	105	4th	29	7th	76	28.0	58	9th	3	19th	15	10	5	7	2.47	.08	S. W.
July	71.6	106	20th	34	9th	72	26.6	52	*7	3	9th	13	13	5	6	2.00	.06	S. W.
August	73.5	103	*8	31	22d	72	27.0	53	25th	6	*9	15	11	5	8	2.96	.09	S. W.
September	69.0	105	*10	25	*11	80	25.0	52	20th	2	....	15	10	5	5	1.66	.06	S. W.
October	46.9	84	*12	8	30th	76	26.0	58	2d	3	*13	17	9	5	4	1.22	.04	S. W.
November	41.3	85	*14	5	21st	80	21.0	53	6th	1	*15	8	9	13	9	4.11	.14	S. W.
December	33.9	79	20th	—13	13th	92	16.0	48	15th	2	*16	7	8	16	10	3.85	.12	S.
Sums and averages	49.9	88	....	8.6	....	72.7	23.4	54.1	....	2.5	....	143	119	103	89	28.46	.07	S. W.

Station—*1 12th, 13th. *2 12th, 18th. *3 11th, 13th. *4 North and Northwest. *5 25th, 26th. *6 2d, 9th. *7 12th, 14th. *8 8th, 18th. *9 14th, 29th *10 12th, 14th. *11 20th, 21st.
State—*1 7th, 21st. *2 3d, 7th. *3 13th, 15th, 30th. *4 1st, 29th. *5 30th, 31st. *6 14th, 17th. *7 8th, 12th. *8 9th, 17th. *9 19th, 20th, 21st. *10 20th, 21st, 22d. *11 15th, 28th.
*12 3d, 5th. *13 8th, 12th. *14 6th, 7th. *15 11th, 25th, 27th, 30th. *16 2d, 3d, 8th, 9th, 14th, 21st.

METEOROLOGY—TABLE VI.

Summary by Years and Grand Summary for Eight Years.

	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	Summary for eight years.
At	Wooster.	Wooster.	Wooster.	Wooster.	Wooster.	Experiment Station	Experiment Station.	Experiment Station.	
Mean temperature	47.6°	48.6°	49.5°	50°	50°	49.3°	50.5°	47.8°	49.2°.
Highest temperature		91.5°, *1	91.5°, Aug. 3.	99°, Aug 8.	98°, July 25.	95°, *5	98°, July 19.	98°, June 4.	99°, Aug. 8, 1891.
Lowest temperature	—5°, Feb. 9.	—5°, *2	1°, March 7	0°, March 1.	—20°, Jan. 20.	—9°, Jan. 11.	—7°, Dec. 28.	—6°, *8	—20°, Jan. 20, 1892.
Range of temperature		96.5°	93.5°	99°	118°	104°	105°	104°	119°.
Mean daily range of temperature		18.7°	18.9°	21°	19°	20.2°	22.9°	21.8°	20.4°.
Greatest daily range of temperature		42°, April 23.	41°, Jan. 13.	42°, Sept. 23.	46°, July 7.	45°, Aug. 9.	45°, July 31.	55°, Oct. 6.	55°, Oct. 6, 1895.
Least daily range of temperature		2°, Jan. 6	4 5°, *3	4°, Feb. 8	4°, *4	30°, *6	4°, *7	1°, Nov. 27.	1°, Nov. 27, 1895.
Number of clear days		125	109	116	116	96	127	125	116.
Number of fair days		103	119	110	123	161	154	117	127.
Number of cloudy days		137	137	125	98	105	84	123	116.
Number of days rain fell		119	149	119	119	129	130	102	124.
Total rainfall	38.25 inches.	39.87 inches.	54.21 inches.	38.36 inches.	38.86 inches.	40.58 inches.	30.60 inches.	31.45 inches.	39.02.
Greatest monthly rainfall	4.54 inches.	6 73 in., July	7.45 in., Oct.	4.26 in., June	7 89 in, June	6.33 in., Feb	4 41 in, May	4.21 in., Nov.	7.89 in., June, 1892.
Least monthly rainfall	1.39 inches.	1 36 in, Oct.	1.74 in., Dec.	1.95 in., Apr	0.37 in, Oct.	1.38 in., July	0.76 in, Aug	1.00 in., Feb.	37 in., Oct., 1892.
Prevailing direction of wind	S	S	S	S	S.W.	S.W.	N.W	N	S.

[1] July 10 and September 1. [2] February 23 and 24. [3] January 8 and September 10. [4] March 5, November 1, 3, 25 and December 1 and 18. [5] July 7, 25 and September 7. [6] January 24, February 11 and May 26. [7] December 1 and 23. [8] January 12, 13 and February 5.

METEOROLOGY—TABLE VII.

SUMMARY BY YEARS AND GRAND SUMMARY FOR THIRTEEN YEARS FOR THE STATE.

	1883.	1884.	1885.	1886.	1887.	1888.	1889.
Mean temperature	49.4°	50.6°	48.0°	49.6°	51.4°	49.5°	51.1°
Highest temperature	98.° Aug. 22	99.0° Sept. 28, Oct. 1	101.0° July 21	98.6° July 7	108.0° July 18	102.0° Aug. 3	99.5° Aug. 31
Lowest temperature	17.2° Jan. 22	—34.0° Jan. 25	—31.0° Jan. 29	—21.5° Jan. 7	—21.0° Jan. 17	—15.0° Jan 27	—13.5° Feb. 24
Range of temperature	115.5°	133.0°	132.0°	120.1°	129.0°	117.0°	113.0°
Mean daily range of temperature	19.8°	20.5°	20.4°	20.2°	21.2°	19.6°	19.3°
Greatest daily range of temperature	55.2° March 18	50.0° Sept. 5, Dec. 4	58.5° Jan. 30	57.0° Dec. 11	57.0° April 11	50.0°	53.0° March 30
Least daily range of temperature	0.5° Dec. 23	1.1° Feb. 6	1.0° April 18, Dec. 31	1.1° March 27	1.0° Jan. 5, April 16	1.2° Jan. 16	1.0° Jan. 5
Average number of clear days	98.2	116.7	103.5	118.4	113.8	108.7	112.8
Average number of fair days	135.4	118.3	132.8	125.7	127.3	123.4	113.8
Average number of cloudy days	130.4	131.1	128.2	121.0	123.9	133.9	138.4
Average number of days rain fell	146.0	145.0	147.7	130.7	120.9	124.7	114.8
Mean yearly rainfall	44.98 inches	40.19 inches	38.08 inches	37.71 inches	33.63 inches	39.64 inches	33.53 inches
Mean daily rainfall	0.123 inch	0.110 inch	0.104 inch	0.100 inch	0.092 inch	0.108 inch	0.092 inch
Prevailing direction of wind	S. W	S. W	S. W	S. W	S. W	S. W	S. W

METEOROLOGY—TABLE VII—Concluded.

	1890.	1891.	1892.	1893.	1894.	1895.	Summary for thirteen years.
Mean temperature	52.4°	52.0°	50.0°	50.10°	52.40°	49.9°	50.50°.
Highest temperature	103.1°, Aug. 3	101.°, Aug. 10	103.°, July 25	102.°, June 19	105.°, July 18-19	106.°, July 20	108.°, July 13, '87
Lowest temperature	—4.0°, March 7	—5.0°, March 5	—25.0°, Jan. 20	—24.0°	—27.0°, Dec. 29	—24.°, Feb. 6	-34.°, Jan. 25, '84
Range of temperature	107.1°	106.°	128.°	126.°	132.°	130.°	142.°.
Mean daily range of temperature	19.°	20.°	19.°	21.7°	23.°	23.4°	20.5°.
Greatest daily range of temperature	49.5°, April 11	50.0°, April 27 30	51.0°, Sept. 25	54.6°	60.0°, Oct. 19	59.° [*3]	60.°, Oct. 19, '94
Least daily range of temperature	1.0°, Dec. 17	2.0° [*1]	1.0° [*2]	1.0°	1.0°, Feb. 7	0.°, Feb. 7	0.°, Feb. 7, 1895
Average number of clear days	103.4	133.	111.	122.	138.	143.	117.1.
Average number of fair days	121.6	109.	126.	123.	126.	119.	123.1.
Average number of cloudy days	140.3	137.	129.	120.	101.	103.	125.9.
Average number of days rain fell	149.4	120.	121.	113.	100.	89.	124.7.
Mean yearly rain fall	50.33 inches	38.61 inches	37.16 inches	39.63 inches	29.75 inches	28.46 inches	37.74 inches.
Mean daily rainfall	0.138 inch	0.110 inch	0.100 inch	0.110 inch	0.080 inch	.07 inch	0.102 inch.
Prevailing direction of wind	S.W.	S.W.	S.W.	S.W.	S.W.	S.W.	S.W.

[*1] Jan. 4 and 11, March 19 and 22, Nov. 12, Dec. 4. [*2] July 29, Nov. 3, 12 and 28, Dec. 17. [*3] Jan. 15, March 29.

NOTES ON THE WEATHER AT THE STATION—SUMMARY BY MONTHS.

JANUARY.

The mean temperature was 21.8°, which is 5.6° below the nine year Station average for January. The highest temperature 54.°, occurred on the 21st; the lowest, —6°,on the 12th and 13th.

Cloudy weather prevailed. Rain and snow fell on fifteen days. The total precipitation was 3.92 inches, which is 0.41 inch below the Station average for January.

The prevailing wind was southwest.

FEBRUARY.

The mean temperature was 17.9°, which is 8.5° below the Station average for February. The highest temperature, 60.°, occurred on the 28th; the lowest,—6°, on the 5th.

Fair weather prevailed. Rain and snow fell on eight days. The total precipitation for the month was 1.00 inch, which is 2.79 inches below the Station average for February.

The prevailing wind was northwest.

MARCH.

The mean temperature was 32.4°, which is 2.3° below the Station average for March. The highest temperature, 59.°, occurred on the 24th; the lowest, 9.°, on the 7th.

Cloudy weather prevailed. Rain and snow fell on eleven days. The total precipitation for the month was 1.98 inch, which is 0.8 inch below the Station average for March.

The prevailing wind was north and northwest.

APRIL.

The mean temperature was 49 5°, which is 1.2° above the Station average for April.

The highest temperature 80.°, occurred on the 25th and 26th; the lowest, 21.°, on the 3d.

Fair weather prevailed. Rain and snow fell on eight days. The total precipitation for the month was 1.69 inch, which is 0.9 inch below the Station average for April.

The prevailing wind was north.

MAY.

The mean temperature was 59.4°, which is 2.1° above the Station average for May. The highest temperature, 94.°, occurred on the 31st; the lowest, 27.°, on the 21st.

Fair weather prevailed. Rain fell on eight days. The total rainfall for the month was 1.38 inch, which is 2.85 inches below the Station average for May.

The prevailing wind was south.

JUNE.

The mean temperature was 69.9°, which is 1.4° above the Station average for June. The highest temperature, 98.°, occurred on the 4th; the lowest, 35.°, on the 7th.

Clear weather prevailed. Rain fell on nine days. The total rainfall for the month 4.20 inches which is 0.51 inch below the Station average for June.

The prevailing wind was north.

JULY.

The mean temperature was 68.6°, which is 3.3° below the Station average for July. The highest temperature, 92.°, occurred on the 19th; the lowest, 42.°, on the 10th.

Clear weather prevailed. Rain fell on six days. The total rainfall for the month was 2.19 inches, which is 0.90 inch below the Station average for July.

The prevailing wind was north.

AUGUST.

The mean temperature was 70.9°, which is 2.5° above the Station average for August. The highest temperature 94.°, occurred on the 10th; the lowest 42°, on the 22d.

Clear weather prevailed. Rain fell on nine days. The total rainfall was 2.30 inches, which is 0.13 inch below the Station average for August.

The prevailing wind was north.

SEPTEMBER.

The mean temperature was 66.5°, which is 3.9° above the Station average for September. The highest temperature, 93.°, occurred on the 11th; the lowest, 34.°, on the 30th.

Clear weather prevailed. Rain fell on six days. The total rainfall for the month was 3.92 inches, which is 0.90 inch above the Station average for September.

The prevailing wind was south.

OCTOBER.

The mean temperature was 44.5°, which is 4.0° below the Station average for October.

The highest temperature, 73.°, occurred on the 3d; the lowest, 19.° on the 30th.

Clear weather prevailed. Rain fell on five days. The total rainfall for the month was 1.15 inch which is 1.48 inch below the Station average for October.

The prevailing wind was northwest.

NOVEMBER.

The mean temperature was 40.4°, which is 3.0° above the Station average for November. The highest temperature, 72.°, occurred on the 7th; the lowest, 18.°, on the 21st.

Cloudy weather prevailed. Rain fell on nine days. The total rainfall for the month was 4.21 inches, which is 0.86 inch below the Station average for November.

The prevailing wind was southeast.

DECEMBER.

The mean temperature was 32.8°, which is 0.3° above the Station average for December. The highest temperature, 61.°, occurred on the 20th and 21st; the lowest, —2° on the 14th.

Cloudy weather prevailed. Rain and snow fell on eight days. The total precipitation for the month was 3.51 inches, which is 1.00° inch above the Station average for December.

The prevailing wind was southwest.

INDEX.

	PAGE
Acknowledgements	XIX
Agriculturist, report of	XXVI
Announcement	IV
Apples, spraying	97
Apple scab	XXIV
Ashmead, W. H., description of insects by	84, 94
Basket worm, the	XXXII
Begg, John, observations on oat-smut	122
Bisulphid of carbon on grape-root worm	89
Black knot—Yellows law	XXXVII, 66
Board of Control, report of	VII
Bogue, L. L., observations on oat-smut	122
Botanist, report of	XXXIV
Bordeaux mixture, formula for	103
Breed test	XXIX
Breinzer, G. W., observations on oat-smut	122
Calculation of rations	38
Cattle feeding. See "Feeding for beef."	
Cattle feeding, chemistry of	31
Chemist, report of	XLIII
Chinch bug, the	XXXII
Chinch bug fungus, distribution of	XXXII
Copper carbonate solution	105
Corn meal vs. wheat meal in feeding	15
Corn root worm, the	XXXII
Corn smut, amount of	XXXIX
Cox, Nelson, observations on oat-smut	122
Cox, U. T., experiments in spraying	97
Creamery, the	XXIX
Crops of the year	XIII
Crotch, G. R., reference to	78
Dairy, the	XXIX
Dehorning experiments	XXVIII
Digestibility of foods	35
Dille, W. W., experiments on grape-root worm	87
Director, report of	XIII
Donations to the Station	XXII
Dupont, E., on oviposition of *Adoxus obscurus*	82
Entomologist, report of	XXXII
Farm improvement	XXX
Farm products	XXX
Fattening cattle. See "Feeding for beef."	
" cattle, effect of temperature on	20
" increase at different periods of	25
Feeding for beef	XV, 7–56
" " cost of increase in	10
" chemistry of	31

PAGE
Feeding corn meal vs. wheat meal 15
" " silage vs. corn stover 17
" heavy vs. light 21
" in barn or shed 24
" oil meal vs. gluten meal 16
" some possibilities in 26
" standards 40
" stuffs, average composition of 48
" " comparative value of 43
" " composition of dry substance 34
" " digestibility of 35
" " fertilizing constituents in 28, 54
" " manurial value of 44
Fertilizers, list of experiments with xxvii
" on potatoes 148
Finishing beeves on grass 21
Fruit plantations xxv
Galls of raspberry, peach and pear xxxix
Gladiolus, scab and rot in xxxix
Gluten meal, feeding 16
Grain-smuts .... xxxvii, 115
Grape-root worm, the .... xvi, xxxiii, 77–95
" " arsenical poisons on 87
" " bisulphid of carbon on 90
" " description of stages 79
" " habits of adult 81
" " " larvæ 83
" " kerosene emulsion on 87
" " natural enemies of 84
" " pyrethrum on 88
" " remedies and prevention for 85
Greenhouses, construction for sub-irrigation 57
Green, W. J. and E. C., bulletin on sub-irrigation .... xvi, 57–76
" bulletin on orchard spraying .... xvi, 97–113
" " potatoes .... xvii, 141–159
" report as Horticulturist xxiv
Harlequin cabbage bug, the xxxii
Hickman, J. F., bulletin on feeding for beef .... xv, 7–56
" report as Agriculturist xxvii
Horn, G. H., reference to 78
Horticulturist, report of xxiv
Howard, L. O., on *Fidiobia flavis* 84
Illinois Station, feeding test at 18
Iowa " " 18
Insects—
Adoxus obscurus 82
Aphis persicæ niger xxxiv
Basket worm xxxii
Brachysticha fidiæ 85–94
Chinch bug xxxii
Feltia herilis xxxii
Fidia lurida 78
" *viticida* 77–95

Insects—Concluded— PAGE
Fidiobia flavis 84–94
" *flavipes* 84–94
Grape-root worm .... XXXIII, 77–95
Harlequin cabbage bug XXXII
Hoplophora arctata 84
Lasius brunneus var alienus 84
San José Scale XXXII
Thrips tritici tabaci XXXIII
Trichogramma acuminatum 95
Tyroglyphus phylloxeræ 84
Web worms XXXII
Western striped cut worm XXXII
Lettuce, culture of, under glass 71
" effect of sub-irrigation on 66
Liver of sulphur. See potassium sulphid.
London purple in spraying 105
McFadden, H. O., bulletin on potatoes 141
Maine Station, feeding test at 19
Manure, value of 27
Manurial value of feeding stuffs 44
Marx, Dr. Geo., identification of insect by 84
Maxwell, J. W., experiments on grape-root worm 87
Massachusetts Station, feeding test at 18
Meteorological summary 161
Michigan Station, feeding test at 19
Missouri " " 19
Mohler, D. M., and Eureka raspberry 110
New Jersey Station, feeding test at 18
Nozzles for spraying 106
Nutritive ratio, the 33
Oat-smut and its prevention .... XVII, 115–139
" amount of in Ohio 119
" botanical characters of 123
" damage caused by 118
" historical notes on 116, 123
" hot water treatment for 130
" life history of 125
" methods of infection 123–125
" " prevention 128
" potassium sulphid for 132
Oil-meal, feeding 16
Onion thrips XXXIII
Orchard spraying .... XVI, 97
Paris green in spraying 105
Peach aphis .... XXXIII, XXXIV
" diseases XXXIV
Peaches, spraying .... XXXV, 103
" leaf curl of XXXIV
" fruit spot of XXXIV
" root galls on XXXV
Peach yellows .... XXXV, 102
Pears, spraying XXXVI
Pennsylvania Station, feeding test at 19
Plant diseases XXXIX

PAGE
Plum scale xxxii
Potassium sulphid for gooseberry mildew 105, 107
" " oat-smut 132
Potatoes, notes on varieties 148
" fertilizers on 154
" southern vs. northern seed 147
" variety tests .... xvii, 141
Printing, the Station's xiv
Publications .... xv, xviii
Raspberries, notes on varieties .... xvi, 108
" galls of xxxix
Rations, calculation of 38
Riley, C. V., on grape-root worm 78
San José scale, the xxxii
Season, the xiii
Selby, A. D., bulletin on oat-smut 115–139
" " " weeds 1–5
" report as Botanist xxxv
" report as Chemist xliii
Selby, F. M., observations on oat-smut 122, 127
Sheep flocks xxix
Silage vs. dry fodder 18
Slade Brothers, experiments on grape-root worm 87
Smut of barley xxxviii
" corn xxxix
" oats, see "Oat-smut."
" wheat xxxviii
Spraying orchards 97
" appliances for 106
" mixture for 103
Station's printing, the xiv
" work xiii
Sub-irrigation in the greenhouse .... xvi, 57–76
Sub-irrigation, cost of watering by 62
" effect on lettuce 66
" effect on soil 63
" general effect of 64
" history of 60
Sub-Stations xiv
Thorne, C. E., bulletin on feeding 7–56
" report as Director xiii
Todd, W. H., observations on oat-smut 122
Treasurer, report of ix
Utah Station, feeding test at 19
Variety testing, difficulties in 141
Variety trials of potatoes 141
Variety notes on raspberries 108
Vergon, F. P., experiments in spraying 97
Vermont Station, feeding tests at 19
Vermont Station, oat-smut at 127
Walsh, B. D., on grape-root worm 77
Webster, F. M., bulletin on grape-root worm .... xxxiii, 77–95
" report as Entomologist xxxii
Web worms xxxii
Weeds along thoroughfares 1

PAGE
Weeds, how cutting destroys 3
" identification of 3
Weed law of Ohio 4, 62
Weeds—
- *Amarantus albus* XL
- *Amarantus spinosus* XLI
- *Atriplex* XL
- Bokhara clover 2
- Bracted plantain XL
- Buffalo bur XL
- Canada thistle XL
- *Carduus arvensis* XL
- Chicory XL
- Field peppergrass XL
- Golden hawkweed XLI
- *Hieracium aurantiacum* XLI
- Horse nettle XL
- *Lactuca scariola* XL
- Map of *Lepidium campestre* XL, XLI
- Melilot 2
- Moth mullein XL
- Narrow plantain XL
- Peppergrass XL
- Pennycress XL
- *Plantago aristata* XLI
- *Plantago lanceolata* XL
- Plantain XL
- Prickly lettuce XL
- Rib grass XL
- Russian thistle XLI
- Smartweed XLI
- *Solanum Carolinense* XL
- *Solanum rostratum* XL
- Sorrel XL
- Sow thistle XL
- Spiny amaranth XL
- Spiny clotbur XL
- Sweet clover 2
- *Thlaspi arvense* XL
- Tumbleweed XL
- *Verbascum Blattaria* XL
- Wheat thief XL
- Wild carrot XL

Weedy plants, study of XL
Western striped cut worm XXXII
Wheat feeding 15
White hellebore, use of 105
Wickham, H. F., reference to 78
Wisconsin Station, feeding test at 19

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